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## NOTICE TO AUTHORS OF PAPERS

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**2. Manuscript.** The manuscript submitted should be an original (not a carbon) copy, and typewritten, double-spaced, with 2–3 cm. margins. The title of the article should be followed by the name and address of the author. If the paper has been presented at a meeting, a footnote giving name of society, date, and occasion should immediately follow the author's name. The usual editorial customs, as exemplified in the most recent issues of the JOURNAL, should be followed as closely as possible.

**3. References and Footnotes.** Each reference to the literature and each footnote should be inserted without a number, as a separate line (or lines) immediately following the word to which it refers in the text. A reference to literature should include, in the order named, the title of book or article, author's name, edition or volume, pages, date of publication, and, in the case of books, publisher's name.

**4. Illustrations.** Not all articles lend themselves to illustrations, but articles which do should be accompanied by as many pertinent illustrations as possible. As a rule, apparatus, particularly if complicated, is best presented by means of line or working drawings. Photographs are sometimes sufficient, however. When both can be obtained, it is generally desirable to include both.

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SVANTE ARRHENIUS

## EDITOR'S OUTLOOK

THE work of Arrhenius is one of many historical reminders that the attitudes of mind which we describe as orthodoxy and heterodoxy creep into science as well as into more emotional fields of thought.

**"The Truth and Nothing But—"**

So far the unorthodox seem to have had all the better of the argument, if argument there be. But that is at least partially because the cards are stacked in their favor. It is the nature of science to progress and nearly all of her greatest advances at first have an air of heresy about them. Those apparent heresies which are really founded on truth endure and become scientific monuments; those which are based on error are overthrown and forgotten. Soon no trace remains to remind the world that the conservatives are sometimes right.

Such considerations may or may not be of interest to the research chemist. The teacher, however, is forced to make a decision. He must either align himself frankly with the conservatives or he must attempt a difficult bit of tight-rope walking. Most teachers, it would seem, choose the former alternative. The reasons are several and vary with the individual teacher. One which is never advanced but which carries considerable weight is that conservative teaching is easiest. It requires but little change in subject matter and less in method from year to year. It imposes no obligation to master any great amount of the science beyond that contained in the average standard text.

But it would be a grave injustice to impute laziness to all or even the majority of those who prefer to "stick to the good, old-fashioned chemistry." Many sincerely maintain that speculations, and subjects upon which there is room for division of opinion, have no place in the instruction of beginners. Although they do not so phrase their beliefs, they feel that elementary instruction should be dogmatic. They contend, in effect, that any other method of presentation weakens the faith of the student in his instructor and in the subject—that it leaves him with the impression that science is all a lot of speculation anyway and that one man's guess is as good as another's.

This view, although laudably based upon a respect for absolute truth and a creditable desire to impart nothing but the truth, is open to attack at several points. Perhaps the most apparent objection is the obvious impossibility of doing what the conservative says he means to do—*i. e.*, of sticking exclusively to absolute facts in the instruction of beginners. In order to do so the course would have to remain purely descriptive and empirical. Very few principles could be introduced, and those only as unexplained and largely unrelated generalizations. If the teacher actually stuck to "absolute facts," his only possible point of contact with the

intellect, as distinguished from the memory, would be the uninspiring one of applied arithmetic.

Of course, he does not really do so. He only sticks to statements which ordinarily pass without challenge—either because they are too unspecific to afford any potential objector an opportunity to get his teeth into them, or because they are so time-honored by usage that every informed hearer unconsciously translates them into modern terms. In reality we know that many of the things customarily taught to beginning students are actually misleading.

But there are further objections to the "absolute fact" point of view. Every good teacher desires to avoid imparting error, but he should also realize that it is not his sole or even his chief function to impart "facts." Unless he can do a great deal more than that he is no better than an animated encyclopedia. He may speak of chemical combination and the laws which govern it, but if he evades the student who really wants to know what makes atoms combine and what holds them in combination by vaguely mentioning "chemical affinity" or "electrical forces," he is doing his best to kill rather than nourish whatever intellectual curiosity that student may possess.

Moreover, the adoption of the dogmatic form of presentation damps the student's interest and imagination by giving him the false impression that chemistry is as dead and finished as arithmetic or Greek.

Finally, the "nothing-but-the-truth" system of instruction raises false notions concerning the infallibility of science. The impression is nowadays far too widespread among the ignorant and the semi-educated that science claims to be infallible. We should combat that impression by showing through our teaching just what science does and does not claim.

The sincere conservative makes one other claim which is worthy of discussion, to wit, that the introduction of such refinements as the electron theory into elementary chemistry confuses the student with too much detail and requires more abstract thinking than he is capable of. Our contention is that a theory which can offer some basis of explanation for the periodic table and the electromotive series and which serves to correlate so many otherwise isolated facts cannot fail to dispel more confusion than it creates. We further submit that the idea of "chemical affinity" or "electrical forces" is fully as abstract (not to say esoteric) as the idea of electron transfer or sharing.

It seems to us that the inability to work and think independently, which is so universally imputed to American students, has its roots in this practice of spoon feeding. Many students are never forced to make a decision. They are not even shown the processes by which others arrive at decisions. Everything is handed to them neatly and conclusively settled. How could they be expected to think independently?

# THE PLATINUM METALS[1]

S. C. OGBURN, JR., BUCKNELL UNIVERSITY, LEWISBURG, PENNSYLVANIA

When one desires to fashion some article from metal which will be permanent, as well as ornamental and useful, platinum or an alloy of platinum with the other metals of this group is his first choice. It matters not whether it is an international metric standard, an electrical contact point, an evaporating pan for the concentration of acids, a dental bridge connection, or milady's favorite brooch.

On account of the permanency of these metals they properly belong to that small group of metals termed "precious" or "noble" by the alchemists, to distinguish them from the so-called base metals, such as lead and copper, which are readily corroded by exposure to atmospheric influences. But this outstanding property is not the sole virtue of this group of substances. They are endowed with many remarkable physical and chemical properties which give them a varied and widespread use, as will be indicated later.

## Historical Sketch

Unlike most of the metals now in common use, platinum remained unknown until comparatively recent times Although "a white infusible metal found in the mines of Mexico and Darien (Panama)" was described by Julius Scalinger in his book "Exercitations Exotericoe de Subtilitate,"[2] it was not until 1735 that the metal was definitely mentioned by name by Don Antonio de Ulloa, a Spanish naval officer. He describes it in the account of his travels to South America with a French Astronomical Mission, in a publication entitled "A Narrative of a Journey to South America." The discovery[3] was made known at the time, but a full account of it was not published until 1748, thirteen years later.[4]

In this account, Ulloa, to whom the discovery of platinum is now usually attributed, refers to the metal under the name "platina" as a definite metallic *mineral* which occurs in the Choco district of Colombia. The name "platina" was used due to the metal's resemblance to silver, the Spaniards having called it "platina del Pinto" ("platina" being the dimin-

[1] Taken from an address delivered before the Central Pennsylvania Section of the A. C. S. at Lewisburg, Pa., May, 1928.

[2] Published about 1600.

[3] In 1741, seven years before the publication of Ulloa's description of the metal, samples of native platinum, said to have been derived from alluvial deposits at Carthagena, in Colombia, were brought to England by Charles Wood, an assayer of Jamaica, to whom the credit of the discovery of platinum is sometimes, though erroneously, attributed. To Wood, however, must be ascribed the credit of having first brought the metal to Europe. (See reference 4.)

[4] "Platinum Metals," E. A. Smith, Sir Isaac Pitman & Sons, Ltd., **1924.**

*Photograph by C. H. Canning* *Courtesy of G. F. Kunz*

PLATINUM IN COLOMBIA

The new town of Andagoya at the confluence of the rivers San Juan and Condolo. Andagoya is the center of platinum-dredging activities on the Condolo.

utive of "plata," the Spanish for silver, and "Pinto," the name of the river in the auriferous sands of which the metal was first found).

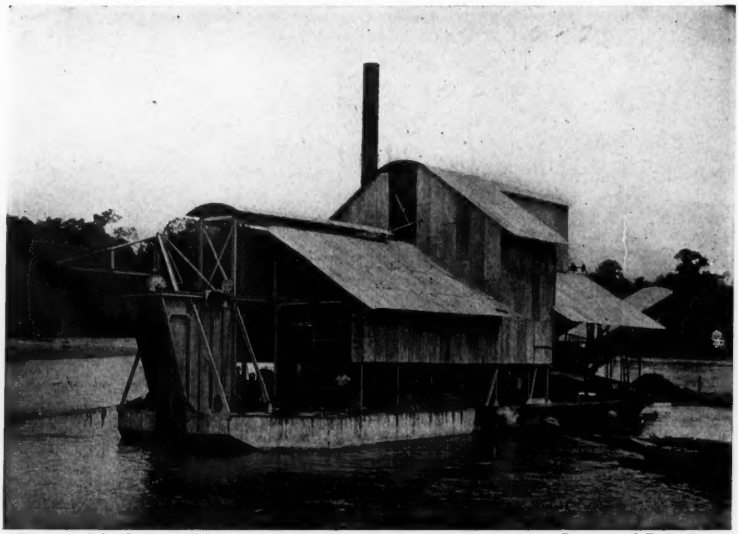
With the dawn of the ninteenth century many serious attempts were made to produce platinum commercially, but slow progress was made until the supply of the crude metal was augmented by the discovery about the middle of the century, of the world-renowned deposits in the Ural mountains, Russia. By continual examination of the crude metal and in the many attempts to purify it and work it up into sheets or foil, investigators soon displayed the fact that the crude metal was not composed entirely of platinum, but consisted of a complex mixture of several metals, which, while somewhat similar to platinum, had very distinct and valuable properties of their own. The results of research not only greatly assisted the development of the technical industry, but early led to the discovery and isolation of the five other metals which, with platinum, are known as the "platinum group;" *viz.*, iridium, palladium, rhodium, ruthenium, and osmium. In nature they all occur associated together in what is commonly known as platinum ore, and they are on this account usually spoken of as the platinum metals.

Each of these latter five metals, except ruthenium, was discovered in the year 1804. Wollaston contributed the metals rhodium and palladium; the former being named from the Greek word meaning a rose, in recognition of the beautiful rose color of aqueous solutions of its salts; the latter being from the planet Pallas, which had been discovered by his friend Olbers in 1802. Osmium and iridium were added by Tennant; the former being named from the Greek word meaning a smell, on account of the characteristic odor of its volatile tetroxide; the latter in recognition of the various colors exhibited by its salts. Ruthenium was discovered by Claus in 1845, who retained a name given to an indefinite oxide, which was considered at the time to be a new metallic element obtained a short time before by Osann.

## Occurrence and Production

These six metals usually occur in the native—that is, in the metallic—state, but alloyed more or less with each other in greyish flakes and in grey or black sands found in alluvial deposits, ordinarily known as "placers." Platinum never occurs pure. The content of platinum in the native grains averages from 70 to 96 per cent, the remainder consisting of the other platinum metals with iron and other base metals. The placer deposits furnish nearly all of the world's supply of crude, or "primary," platinum. These deposits have been formed by the erosion of the older ultrabasic igneous rocks, such as serpentine and dunite, and the crude platinum, either in the form of approximately spherical grains or flattened ones, has accumulated in association with chromite, magnetite, gold,

quartz, iridosmine, etc., due to their high density and resistance toward weathering processes. The alloy of iridium and osmium containing some ruthenium is called iridosmine, or osmiridium, depending upon which metal predominates, and is found in Tasmania, Australia, and New Guinea. Certain sulfide ores of copper, nickel, iron, and arsenic contain an arsenide of platinum ($PtAs_2$) and are treated for its recovery. This is especially true of those ores in the Sudbury (Ontario) and Laramie (Wyoming) districts. In the recently discovered South African deposits, the crude ore is found disseminated in the pyroxene belt of intrusive rock in mag-



*Photograph by C. H. Canning* *Courtesy of G. F. Kunz*

A DREDGE WORKING IN THE CONDOLO RIVER OF COLOMBIA

Platinum is found in great quantities, although not frequently, in the auriferous sands of several Colombian rivers.

matically segregated zones from which, according to Kunz,[5] 70% of the platinum can be recovered.

Of the total world production to date (some 11,500,000 troy ounces), Russia has contributed about 90%, Colombia 7%, Borneo 2%, and the remaining 1% has come from the United States, Australia, Canada, and, very recently, South Africa (Central Transvaal). The world production of crude platinum from placers in 1926 has been estimated[6] as about 127,000

[5] "Platinum," G. F. Kunz. Chapter in "Mineral Industry during 1925," page 571. Edited by G. A. Roush, McGraw-Hill Book Co., 1926.

[6] "Platinum and Allied Metals," James M. Hill. Bureau of Mines paper, 1: 2, Mineral Resources of the United States, 1926, part I, pp. 9–18, published Sept. 3, 1927, U. S. Govt. Printing Office.

troy ounces. In the United States the new platinum metals recovered by refineries totaled 85,000 ounces, of which 88% was of foreign origin. Secondary platinum metals (or those recovered from scrap metal and waste products of manufacture) amounted to about 50,000 ounces. The imports of these metals in that year amounted to about 135,000 ounces with a value of $13,451,835. Of this amount the valuation of the platinum was $11,804,355; the iridium, $411,646; the iridosmine, $64,714; the osmium, $594,042; the palladium, $460,015; the rhodium, $78,907; the ruthenium, $38,256. The exports from this country were (for platinum) 11,573 ounces of unmanufactured and 1898 ounces of manufactured goods.

## Values and Uses

The price quoted at present (September, 1928) on the refined metals runs from $46 per oz. for palladium to $280 per oz. for iridium. Probably no other series of metals or group of commercial commodities fluctuate in price within so brief a period as do the metals of the platinum group. In 1926, the quotations on platinum ran from a minimum of $101 per oz. to $120 per oz.; on palladium, from $63 to $83; on iridium, from $115 to $390; the average selling price of osmium was $78, of rhodium $77, and of ruthenium $69. Many factors, economic, political, and industrial, play a part in such fluctuations and it is quite difficult to predict market values even a few weeks in advance of a purchase.

The two outstanding features of the platinum situation within the past two years have been: (1) the continued and enlarged development in South Africa of new platinum mine areas; (2) the renewed activity of the Soviet government in not only mining the Ural deposits but also in establishing refineries and manufacturing plants to produce finished platinum ware. In connection with this latter point, it might be mentioned that recently seventeen carloads of new dredging equipment were shipped from Marysville, California, consigned to the Soviet government, and four more consignments of nearly the same size are in the process of shipment. The platinum which has been stored in London by the Soviet government represents the security for credits granted by the banks to the Russian trade organizations in London, and doubtless these quantities will not be offered to the world market within a short time.[5] Of course, that government has no interest in overstocking the market, and has ordered its Commissioner to regulate the offer according to the demand. (It is also interesting to note that in 1926 there were in stocks in this country a total of 105,571 ounces of platinum metals, a gain of nearly 27,000 ounces over the previous year.)

A variety of opinions as to the importance of the South African de-

posits has been expressed. Some persons maintain that the deposits are of too low a grade and too irregular in occurrence ever to amount to much, while others claim that South Africa will soon be able to supply the world's demand, and to force a considerable reduction in price. G. F. Kunz,[5] writing in the "Mineral Industries for 1925," states that a great combine is planned to establish a platinum market in London, and that negotiations have been made with a view to handling all sales of South African platinum. "This," he says, "is evidently the result of expectations felt by many that the new supply in this vicinity is almost unlimited in amount and bids fair to flood the market unless some such precautions as this are taken. Action of this kind is a logical following of the procedure

*Courtesy of G. F. Kunz*

COUNTERFEIT DOUBLOON OF ISABELLA II OF SPAIN (1833–1868), DATED 1856

This coin, seven-eighths of an inch in diameter and weighing about 13 grams, was struck of platinum and then gilded to imitate gold. The worth of a genuine gold coin of this type at the time was about $7.87, while the platinum in it was worth not more than $1.70. Today, however, the counterfeit is worth about $42 or more than five times its weight in gold.

of the South African diamond producers in the formation of the Diamond Syndicate."

Colombian production has been increasing very rapidly of late. Russia has stabilized her production under state control. South African deposits are in the hands of many speculators and new companies, about two-thirds of which have failed before any material amount of metal has been sold. But there are at least two companies which are mining rather large quantities profitably and which may be expected to increase their outputs.

Whether or not these facts have caused the recent downward trend in the prices of all of the platinum metals, I would not say. But the fact

remains that at least a combination of such factors has very materially affected this market.

These metals find wide usage in four major fields: the chemical, electrical, dental, and jewelry industries. They are used in the manufacture of apparatus, catalyzers, electrodes, incandescent lamps, furnace coils, contact points, thermo-couples, x-ray tubes, pins, wire, alloys, radio vacuum tubes, lightning rod tips, gas engine tubes, cautery points, chemical compounds, etc. The dental and miscellaneous uses have shown, within the past several years, an appreciable decline, leaving for the chemical, electrical, and jewelry uses an increase of well over 10,000 ounces a year. About 60% of this is consumed by the jewelry industry and about 20% each by the chemical and electrical industries. Of all the platinum metals used in the United States in 1926, 6.32% was used by the chemical industries; 12.87% by the electrical industries; 11.51% by the dental manufacturers; 56.54% went into jewelry; and 12.76% was distributed over miscellaneous fields.

## Properties of the Metals

As is the case with most metals, their uses are expressions of the practical application of their inherent properties. Properties determine the uses. These metals are very closely related to each other, but may be divided into two series. The light series, ruthenium, rhodium, and palladium, have specific gravities ranging from 11.3 to 12, atomic weights from 101.7 to 106.7, melting points from 1549° to 2450°C., and principal valences from three for rhodium to either three, four, six, or eight for ruthenium. As you proceed from ruthenium to palladium their specific gravities decrease while their atomic weights increase. The heavy series—osmium, iridium, and platinum—have atomic weights ranging from 190.9 to 195.2, specific gravities from 21.5 to 23.0 (osmium being the densest substance known), melting points from 1755° to 2700°C., and principal valences from two or four for platinum to two, three, four, or eight for osmium.

Of similar color they are very refractory and, with the exception of palladium, are extremely difficult to get into solution. The two most prominent members of the group are platinum and palladium. These are readily distinguished, however, by placing a drop of aqua regia on the specimen. Platinum slowly dissolves without staining, while palladium is readily attacked and leaves a brownish coloration. These metals are among the most permanent substances known. They are unaffected by air or by oxygen at ordinary temperatures and, with the exception of osmium, are scarcely oxidized by oxygen at *any* temperature. The closeness of the similarity of their properties can be understood when it is noted that they differ but little in their atomic structure. The atomic members of the metals of the light series run 44, 45, and 46; those in the heavy series

run 76, 77, and 78, and they have, along with iron, cobalt, and nickel, presented a problem in the periodic arrangements of the elements.

### Separations and Analyses of These Metals

On account of their wide usage and most remarkable properties, these metals have long been a subject of investigation. A multitude of their compounds have been prepared, but in a matter so important as their separation from each other much has been attempted while relatively little has been accomplished. Many of the metals which have a more limited field of application can be separated and analyzed with a greater degree of speed and accuracy.

Concerning the detailed schemes used by the large platinum refineries of the world, little finds its way into the literature. The separations generally listed are dependent upon whether one requires a knowledge of the presence of one or two of the metals in a sample; whether he wants a qualitative knowledge of the whole group; or whether he desires a complete quantitative separation. This confusion is not a desirable one nor have the scientific investigators of the past been idle in their attempts to get something tangible, simple, yet complete. Drs. Edward Wichers[7,8] and Raleigh Gilchrist,[8,9] Mr. William Swanger,[8,10] and others of the Bureau of Standards have contributed some excellent work along these lines during the past few years.

The close analogy of the platinum metals with each other and the remarkable manner in which the relations of each to chemical reagents are controlled *by the presence of the others*, give rise to many difficulties. It has become quite common to speak of the "eccentric properties of the metals," with regard to their chemical behavior both separately and in a mixture of themselves. One might obtain a given reagent which would react quantitatively in removing one of the metals from a pure solution of one of its soluble salts, but when the same separation is repeated in the presence of other metals in the group this removal might not prove quantitative. The writer has met this situation in several instances, although the interfering metal was not itself precipitated or visibly affected. The catalytic effects which can be exhibited in aqueous or alcoholic solutions of these metals are well known. In some cases where alcohol is used as

[7] "Investigations on the Platinum Metals. VI," E. Wichers, *J. Am. Chem. Soc.*, **46,** 8 (1918). See also other papers of this series.

[8] "Purification of the Six Platinum Metals," E. Wichers, R. Gilchrist, and W. H. Swanger, Am. Inst. Mining & Met. Engrs. Tech. Pub., No. 87. (Issued with *Mining & Metallurgy*, March, **1928.**)

[9] "Investigations on the Platinum Metals. IV," R. Gilchrist. Scientific paper of the Bureau of Standards, No. 483.

[10] "Analysis of Dental Gold Alloys," H. Swanger. Scientific paper of the Bureau of Standards, No. 532.

*Courtesy of G. F. Kunz*

THE DEMIDOFF NUGGET

This platinum nugget, the largest ever found, weighs 7837 grams (approximately 21 pounds, troy) and is deposited in the Demidoff Museum at Petrograd.

the solvent for a given organic reagent, it is oxidized, on boiling in contact with an aqueous solution of some of these metals, to acetic acid. This latter acid in some cases might dissolve any precipitate formed by the reagent.

The early methods of purification and extraction of the individual metals from natural mixtures are today very little modified in the field of their metallurgical separation, which involves, in part, fusions, distillations, alloy formations, and fractional precipitations.[11] It is a striking fact that of all the metals known, only osmium and ruthenium form volatile oxides in an aqueous solution and this property has been successfully utilized in their separation from others of the group. Osmium is easily oxidized in *acid* solutions by such agents as nitric acid, aqua regia, chlorates, etc. When such a mixture is boiled, the volatile $OsO_4$ distils off and may be collected in alcoholic potassium hydroxide, which precipitates the osmium as potassium osmate. Ruthenium may be similarly distilled from an *alkaline* solution under the influence of the passage of a stream of chlorine gas. The $RuO_4$ may be collected in dilute hydrochloric acid, yielding ruthenium chloride. The remaining metals are variously treated in their separation. Rhodium may be removed by fusion with potassium acid sulfate, which yields a soluble double sulfate; platinum and palladium may be removed by dissolving the sample in aqua regia, precipitating the palladium with an alcoholic solution of dimethylglyoxime, and the platinum with a saturated solution of ammonium chloride. The iridium residue containing some of the other metals may be fused with lead, the button extracted with aqua regia to remove platinum or palladium, heated in hydrogen and weighed. Even under these conditions it is very difficult to effect a complete separation. Fusions with potassium chloride in a current of chlorine followed by a reduction process are usually resorted to.

The actual success of such a scheme of analysis is contingent upon many factors. It is, at its best, fractional; the various separations have to be repeated, precipitates dissolved, and the metal reprecipitated several times to remove the metal sought from traces of the others present. It is difficult to perform accurately and requires the care and painstaking efforts of the most careful and experienced analyst who is thoroughly familiar with the interfering tendencies of the metals in a mixture of themselves. It is a long and laborious process but has been known to yield some very accurate results. It is evident that for many purposes such a scheme is not applicable. If a short gravimetric scheme of analysis could be developed—if one could, by the addition of successive precipitating reagents, isolate the various members of the group in the presence of those remaining—what a saving in time and energy would result.

During recent years some work on the precipitation and separation of

[11] As the Deville and Stas method. See reference 9.

these metals has been done but, almost without exception, the authors have limited themselves to the separation of only one, two, or three of the series and not of the whole group. Both organic and inorganic reagents have been used. In most cases with inorganic compounds and with the basic organic compounds (such as alkaloids, amines, and substituted naphthols), the metal, in acid solution, reacts with the formation of salts or addition products which are more or less insoluble, thus affording their removal. With certain organic compounds (such as the dioximes and hydroxyquinolines), however, organic derivatives of the platinum metals, whose structural constitutions are quite complex, are formed. The most typical of these are the coördinated or so-called "inner" salts. Their formation, according to Lowry,[12] depends upon the formation of complexes in which the electrons in the outer shell of the metal are made up to the number present in the next inert gas by a process of sharing electrons with coördinated groups. In the case of the dioximes, the complex contains two electrons less than the number required to complete this total. These compounds are remarkably stable. They are insoluble and non-ionizable and in some cases extremely difficult to break up so that the metal may be obtained for a weight determination as such.

These facts prove the importance of the use of the glyoximes as precipitants for platinum and palladium—but what of the other members of the series? Is it not possible to find certain other atomic arrangements which will form stable and insoluble bodies such as to permit their use in the separation of the other metals of the platinum group? In the furtherance of this quest the writer tried the effect of some thirty-three typical inorganic compounds on dilute solutions of the six metals; also, of some ninety typical organic compounds representative of most of the classes of such compounds.[13] These tests were carried out in cold and hot, dilute and concentrated, and in acid and alkaline solutions. The results obtained were then tabulated in a systematic way to obtain a comparison of the chemical constitution of the precipitating radical with its effect in removing the metal from solution or in giving a typical color reaction which might be useful in identifying that metal.

From these tables the following conclusions were drawn:

1. In general, the most reactive classes of inorganic compounds, acting with the formation of metallic precipitates, are the sulfides, thiosulfates, hydroxides (caustic), halides, certain reducing agents (as hydrazine, hydroxylamine, and phosphorus), and certain metals (as zinc or magnesium) more highly electropositive than platinum. Most of the precipitates are

[12] "The Use of Coördination Compounds in Analysis," T. M. Lowry, *J. Soc. Chem. Ind.*, **42**, 462, 316 (1923).

[13] "Some New Analytical Reactions of the Platinum Metals," S. C. Ogburn, Jr., *J. Am. Chem. Soc.*, **48**, 2493 (1926).

formed in weak hydrochloric acid solutions, but in the case of the reagent hydrazine an alkaline medium is best.

2. In general, the most reactive types of organic compounds are the alkaloids, oximes, aromatic amines, non-substituted nitrosohydroxy compounds, nitroso aromatic amines, pure hydroxy compounds, and amino-hydroxy compounds.

3. There is a marked difference in the apparent ease with which these metals act toward both classes of reagents with the formation of insoluble compounds and definitely colored solutions. The metals arranged according to the number of precipitates or color reactions produced with the total number of reagents tried would fall in the order: *palladium, platinum, rhodium, osmium, ruthenium, and iridium*, respectively. This order has no obvious relationship to the order of their atomic weights or atomic numbers—this being, in terms of their increase, ruthenium, rhodium, palladium, osmium, iridium, and platinum. It does however tend to show a definite relationship between the number of planetary electrons in the next to the last orbit (the orbit furnishing the "secondary valence") in each metal to the precipitation of that metal with the formation of complex salts.

In the five orbit series (ruthenium, rhodium, and palladium), there are respectively 14, 15, and 16 electrons in the fourth orbit.[14] In the six orbit series (osmium, iridium, and platinum) there are respectively 14, 15, and 16 electrons in the fifth orbit. Hence, it is safe to assume that, with the exception of iridium, *the nearer the platinum metal approaches its saturation value, in terms of electrons, in the next to its last electronic orbit, the more reactive is that metal toward the formation of coördinated salts.*

4. Several new color reactions for qualitatively detecting individual members of the group in a pure solution (*i. e.*, in the absence of other members of the group) were found. (1) For *ruthenium*—a deep violet solution results on boiling with phloroglucinol (after the ruthenium solution has been made alkaline with potassium nitrite); a blue solution on warming with allyl-thio-urea; a deep violet solution on warming with *p*-nitrosophenol. (2) For *osmium*—on warming with aniline sulfate solution potassium osmate yields a deep rose solution, while potassium chloro-osmate yields a violet one; a deep blue solution is obtained with *b*-naphthylamine hydrochloride, pyrocatechol, or pyrogallol. (3) For *iridium*—a deep blue solution is obtained on warming with aniline sulfate. (4) For *platinum*—a blood-red solution that changes to dark brownish red results on boiling with pyrocatechol or pyrogallol; and, when the platinum solution is rendered ammoniacal, the same coloration is produced with resorcinol.

[14] "Periodic Chart of the Atoms," H. D. Hubbard, W. M. Welch Mfg. Co., Chicago, Ill.

Using the indications so manifested in these reactions, a number of possible schemes of analysis were outlined and tried. The final scheme developed is herewith summarized.[15]

## A Short Gravimetric Scheme for the Separation of the Platinum Metals

Solution in dilute HCl (7–8 cc. conc. HCl per 100 cc. soln.) of chlorides (or double chlorides) of **Pd, Pt, Rh, Ru, Ir,** and **Os.** *Add 1% alcoholic soln. of dimethylglyoxime in the cold. Filter.*

Precipitate—$Pd(C_4H_7O_2N_2)_2$

Filtrate. *Add excess 2% alcoholic α-furil-dioxime soln. and a quantity of alcohol equal to 10% of the total volume, and boil. Filter.*

Precipitate—$Pt(C_{10}H_7O_4N_2)_2$

Filtrate. *Conc. by evaporation. Add HCl and $NaClO_3$ (to remove excess of oximes). Add alcoholic $KNO_2$ soln. until the whole is alkaline, boil, and let stand over night. Filter.*

Precipitate—$K_3Rh(NO_2)_6$

*Dissolve in aqua regia, evaporate with conc. HCl, dilute, add Mg turnings*—metallic **Rh** ppts.

Filtrate. *Boil until nitrogen oxides and alcohol have been removed. Make acid with conc. HCl. Evaporate nearly to dryness. Dilute. Add alcoholic NaOH and boil. Filter.*

Precipitate—$Ru_2O_3 \cdot 3H_2O$

*Dissolve in HCl, add Zn dust*—metallic **Ru** ppts.

Filtrate. *Evaporate to remove alcohol. Make distinctly acid with HCl. Add metallic Zn. Filter.*

Residue contains metallic **Ir** and **Os.** *Discard filtrate.*

*Treat above residue with fresh soln. NaOCl. Filter.*

Precipitate—metallic **Ir**

Filtrate. *Make acid with HCl. Add Zn dust. Filter.*

Precipitate—metallic **Os**

Each of the metallic precipitates is subsequently dried, ignited in air (osmium to 190°C. only), heated in hydrogen, cooled, and the metal weighed. Although the palladium precipitate, $Pd(C_4H_7O_2N_2)_2$, and the platinum compound, $Pt(C_{10}H_7O_4N_2)_2$, may be simply washed, dried, and weighed as such, and the percentage of the metals therein calculated,

[15] "A Qualitative Separation of the Platinum Metals," S. C. Ogburn, Jr., *J. Am. Chem. Soc.*, **48,** 2507 (1926).

it is often desirable to convert these to the metallic condition by the usual ignition in hydrogen process.

This gravimetric separation is short and comparatively easy to carry out for those unfamiliar with the detailed chemistry of the metals. It is well adapted for qualitative or quantitative determinations. In some recent analyses made the accuracy of the procedure was under 1.5% for each of the metals. While this percentage of error is not as low as could be desired, it must be borne in mind that very small quantities of each of the metals (about 10 milligrams per cc.) were used and there is no doubt that when larger quantities of the metals are used this error will be materially reduced.

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**Chemistry Seen as Aid to Spice and Food Industries.** Spices, their essential constituents and the composition of their oils, which are closely related to the essential oils that give the delicate fragrance to perfumes, are a neglected branch of chemistry, members of the American Chemical Society were told by John Glassford at the Swampscott meeting.

The chemist has a large field here for research, particularly in view of the double rôle of spices as preservatives and as flavors. Pickles, condiments, mayonnaise, and other salad dressings are included in the field. Problems of fermentation and preservation require study and solution.

At the same meeting, the relation of chemistry to the citrus products industry was discussed. The use of the fruit in the fresh fruit market is but a small part of the industry. Citric acid, lemon and orange oils, concentrated lemon and orange juices, beverage sirups, peel products, and pectin are the by-products of this industry, and with them chemistry may play a large part. Pectin, used under various trade names as a jelly-making compound, requires the most careful attention to every detail of production and use, C. P. Wilson told members of the society.—*Science Service*

**Christmas Lilacs Forced with Ethylene Dichloride.** Lilacs, flowering almonds, and other shrubs of springtime can now be induced to blossom for Christmas decorations, Dr. F. E. Denny of the Boyce Thompson Institute for Plant Research told the Society of Chemical Industry at its recent meeting in New York. The trick is a very simple one which any florist can easily equip his plant to perform; it consists in exposing the potted plants to the vapor of ethylene dichloride or ethylene chlorhydrin, both of which are now obtainable in the chemical market, in a tightly closed room.

Dr. Denny demonstrated the great sensitivity of various plants to this awakening gas treatment. Two twigs on the same branch, as much alike as possible, were selected. One of them was left untreated, the other given the gas. The treated specimen responded while the untreated one remained dormant. The same experiment was repeated, using a pair of buds on the same twig, with similar results.

Dr. Denny has applied various chemical "awakeners" to a considerable variety of plants that usually demand several months of dormancy before they will resume growth. He has succeeded in getting seed potatoes to grow soon after harvesting. This is of considerable commercial importance in the Florida and West Indian potato-growing areas, where two crops can be grown each year, but where the obstinate dormancy of the seed tubers has hitherto forced the growers either to hold them in expensive cold storage for months while they make up their minds to grow, or else to import their seed stock from the North and run the risk of having it diseased when they get it.—*Science Service*

# THE PROCESSES OF COLOR PHOTOGRAPHY. I. EARLY HISTORY

C. E. K. MEES, EASTMAN KODAK COMPANY, ROCHESTER, NEW YORK

From the beginning of photography, it must have occurred to everybody who has taken photographs that it would be an enormous advantage if the photographs could reproduce not only the lights and shades but also the color of natural objects. Charles Kingsley, who was an ardent devotee of the photographic art at the time when he had to make his sensitive materials for himself and when the taking of photographs meant a serious study of applied chemistry, talks in one of his books of the possibility of a time when the photography which he was using to depict the form and texture of his much-beloved plants and animals would be able to show as well the natural living colors of the objects; but these dreams remained only dreams until the day in 1861 when Clerk Maxwell, at that time the greatest physicist of the world, and one of the greatest who have lived, lectured before the Royal Institution in London on his theory of vision, in which he held that the eye has three color sensations, separate sets of receiving organs being responsible for the perception of red, and of green, and of blue-violet, and that all colors are perceived as mixtures, to different extents, of these three primary colors. To illustrate this, Maxwell had taken three photographs, one through a red solution, one through a green solution, and the third through a blue solution, and from these three negatives he had made three lantern slides which he threw on the screen on top of one another by means of three lanterns, each one projecting its slide through the solution which had originally been used for taking the negative. From these three primary colors—red, green, and blue-violet—in the correct proportions, any color can be obtained. Thus, if red light is thrown on the screen and green light added to it, we shall get first orange-red and then orange, which, as the intensity of the green grows in proportion to the red, finally becomes yellow. Similarly, the addition of green to blue-violet produces shades of blue-green and finally of pure bluish green exactly opposite to the red sensation in color, while mixtures of red and blue produce all possible shades of violet, ranging through magenta into purple (see Figure 1). Since the three colors together generate white when they are mixed in equal proportion, we can dilute any of the strong colors—red, yellow, orange, green, blue-green, or blue-violet—by the addition of one or two other colors.

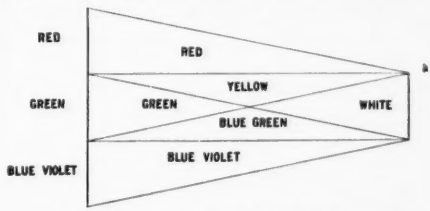


Figure 1.—Mixture of Three Primary Colors to Produce White Light.

The next landmark in the history of color photography was a little book in French by Louis Ducos du Hauron published in 1869 under the title "Les Couleurs en Photographie." In this, du Hauron explained the analysis of light into three primary colors and proposed the obtaining of three negatives through three color filters, but instead of proposing that the pictures should be projected on the top of one another, he suggested two other methods of combining the colors to obtain a finished picture. One of these processes has since become of very considerable practical importance in color photography and is now known as the "screen plate" process. Du Hauron suggested that the surface of a glass plate or film might be covered with tiny unit filters and a sensitive emulsion coated on top of this. Exposures are made through the color filters, so that the image is cut up into a number of little sections—so small that they are invisible to the eye, each section being taken through one of the filters. If the emulsion is so treated in development that a positive is obtained, this will give a direct photograph in colors. This process was realized on a commercial scale in the Lumière autochrome plate, which was first put on the market in 1907.

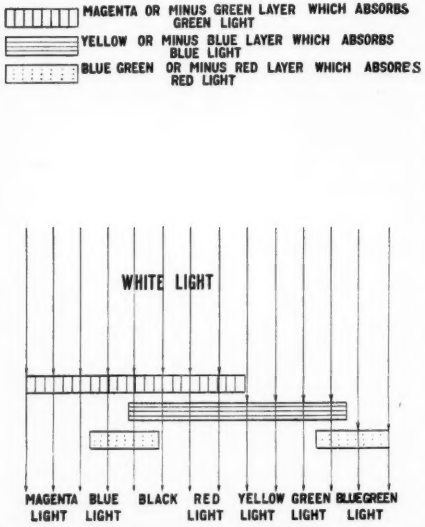


Figure 2.—Diagram Showing Rendering of Colors by the Three-Color Subtractive Process.

Another process which was discussed at greater length by du Hauron is that which is now known as the "subtractive" process. When a color picture is projected on the screen by means of a three-color projection lantern, the pictures made in this way, by adding three different lights, are said to be made by the "additive" process. Suppose, now, that over a sheet of yellow gelatin, which will absorb blue light, is put a sheet of magenta gelatin, which will absorb green light; then, since the yellow absorbs the blue light, and the magenta the green light, only red light is transmitted. A red image can thus be obtained either by projecting it through a red filter or by putting a magenta image on the top of a yellow one. In the same way, a green image can be obtained by putting a blue-green one on the top of a yellow one, when the yellow will cut the blue out of the blue-green and leave only green (see Figure 2).

In working the subtractive process, the three negatives are taken just as for the additive process, and then positives are printed in some way which enables them to be made of a colored material, the commonest being to make them by dyeing gelatin. If gelatin is soaked in bichromate of potash and then exposed to light, it becomes insoluble in hot water where the light has acted upon it, so that if a sheet of film coated with gelatin containing bichromate of potash be exposed under a negative, and then washed in hot water, the gelatin will be left in its full thickness where the light has acted strongly upon it, and washed right away where the negative has prevented the light acting, the picture being represented by the thickness of the gelatin. If this is ordinary gelatin, the picture will scarcely be visible, because the gelatin is so transparent that the difference in its thickness is imperceptible; but if it is soaked in a dye solution, the gelatin will be colored according to its thickness, and the picture will be represented by the varying depth of colored dye. By this process, the three negatives can be printed in colored dye, the picture taken through the red filter being printed on gelatin dyed blue-green, the one taken through the green filter on gelatin dyed magenta, and the one taken through the blue filter on gelatin dyed yellow; and, now, if the three are cemented together in register, the resulting transparent color picture will reproduce the colors of the original subject, and will be of a transparency which can be viewed in the hand or examined in front of an artificial light or projected in a lantern. This process gives very good results. It is a little difficult to get the gradation of such a picture first-rate, and the registration of the three different pictures is not very easy, but the results are splendid; it is however not at all easy to work. The making of the three different negatives itself offers difficulties, and the printing and dyeing of the gelatin reliefs so as to get them all printed alike and all developed to the same extent are so difficult that the process has not yet been a commercial success.

We thus see that there are three distinct processes of color photography which must be borne in mind in any consideration of the discussion:

(1) The additive processes, in which the three positives are projected through their corresponding filters on to a screen.

(2) The screen plate processes, in which the unit filters are so small that they are invisible but in which the process is still essentially an additive one.

(3) The subtractive processes, in which the filter negatives are printed in their complementary colors, and these prints are then superimposed.

In the early experiments, such as those of Maxwell or Ducos du Hauron, the greatest difficulty which was encountered was the lack of sensitiveness to red and green light which was shown by the photographic materials

which were then available. At that time, the process used for making negatives was what is known as the wet collodion process. A glass plate was coated with a solution of collodion in alcohol and ether which contained metallic iodides and bromides in solution. This was sensitized by dipping into a bath of silver nitrate, which formed silver iodide and bromide in the film, and the plate was exposed while it was still wet, since it lost sensitiveness on drying. After exposure, it was developed with a weak reducing solution, such as gallic acid, by which silver was deposited from the silver nitrate on to the latent image formed in the camera, all these operations being carried out immediately after exposure, and portable dark room equipment being used for pictures taken away from the laboratory. A wet collodion plate has almost all its sensitiveness in the extreme violet and ultra-violet, being scarcely sensitive at all to red or green light, so that Maxwell had great difficulty in obtaining records through the red and green filters; in fact, he states in his lecture that this was the cause of the unsatisfactory results which he was able to throw on the screen.

When the gelatino-bromide process was discovered, the sensitiveness of the emulsion produced by it was still confined to the blue-violet and ultra-violet regions of the spectrum, and sensitiveness to the green and red was not obtained until Vogel, in 1873, discovered when working with collodion emulsion that, if he added to the emulsion some dye (Vogel used eosine), it became sensitive to the yellow-green region of the spectrum which is absorbed by the eosine dye. Emulsions sensitized in this way are called "orthochromatic."

In order to measure the color sensitiveness of photographic materials, it is customary to photograph a small spectrum produced by a diffraction grating. In front of the slit of the spectroscope, there is placed a black glass wedge by which the intensity of the spectrum is graduated, so that at the bottom the spectrum has its full intensity and at the top it is decreased to a very small amount. When a photograph is taken, the height

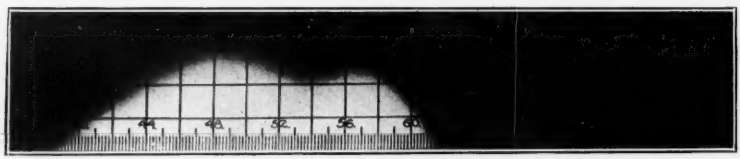


Figure 3.—Spectrum of Orthochromatic Plate.

of the spectrum obtained corresponds to the sensitiveness of the material, and in Figure 3 we see the spectrum of an "orthochromatic" plate photographed in one of these instruments.

The position of the different parts of the spectrum is measured by the length of the waves of light corresponding to each color. Figure 4 shows the range of the visible spectrum, the numbers representing the lengths of

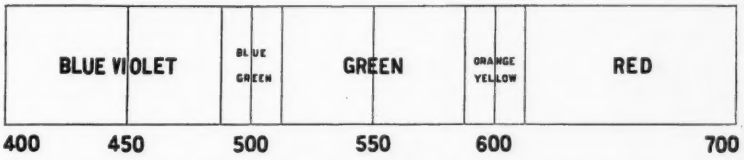


Figure 4.—Diagram of Visible Spectrum.

the waves in $m\mu$, which is a millionth of a millimeter, and the color ranges being indicated. It will be seen that the visible spectrum extends from 400 to 700 and is equally divided into regions which may be broadly termed "violet" (400 to 500); "green" (500 to 600); "red" (600 to 700). These three spectral regions correspond approximately to the three filters used in color photography, but the filters actually used overlap, the red filter, including the orange-yellow regions, shown in Figure 5; the blue filter, both the blue-violet and the blue-green regions; and the green filter, both the orange-yellow and the blue-green regions; so that the green filter overlaps both of the other two to a small extent.

Now, turning again to Figure 3, we see at the left a region of high sensitiveness with a maximum at about "49;" that is, 490 $m\mu$. This is the region of normal sensitiveness of the silver bromide emulsion. The sensitiveness goes down, and then there is another maximum at 57, which is that conferred by the dye.

Soon after 1900 a whole series of new sensitizing dyes was discovered chiefly by Dr. Koenig and his colleagues at the Hoechst Dye Works, and these sensitizers make the emulsion sensitive to the entire spectrum, so that emulsions sensitized with them are termed "panchromatic." The

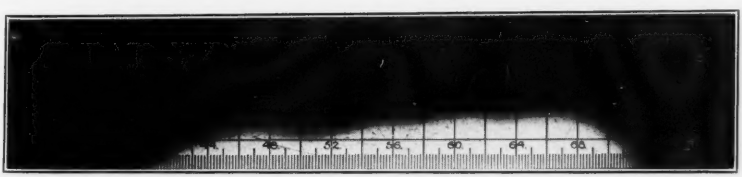


Figure 5.—Spectrum of Panchromatic Plate.

spectrum of a panchromatic plate is shown in Figure 5. By the use of the best of panchromatic materials, photographs can be taken through red or green filters almost as easily as they can be taken without a filter,

although the filters increase the exposure required, about ten times the exposure without a filter being required.

Aside from improvements in the emulsion, great improvements in the filters have been made since Maxwell's time. Instead of glass-walled tanks filled with solution such as Maxwell used, it is now possible to obtain color filters consisting of dyed gelatin cemented between pieces of glass, which are not only more convenient to use but which also give better results than the solutions which Maxwell had at his disposal. It is the improvement in the sensitizing of the plates and films and in the making of the filters which has made all improvements in color photography possible.

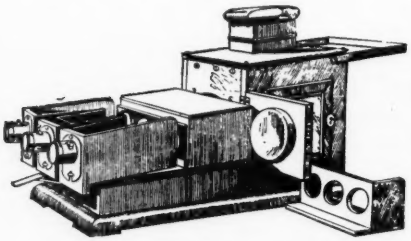

Figure 6.—Ives' Triple Projection Lantern.

The method of obtaining color photographs by taking three negatives through three-color filters—making from them three positives, and then projecting them again through filters similar to those through which they

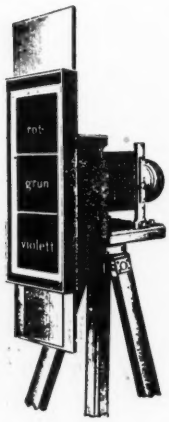


Figure 7.—Miethe Three-Color Taking Camera.

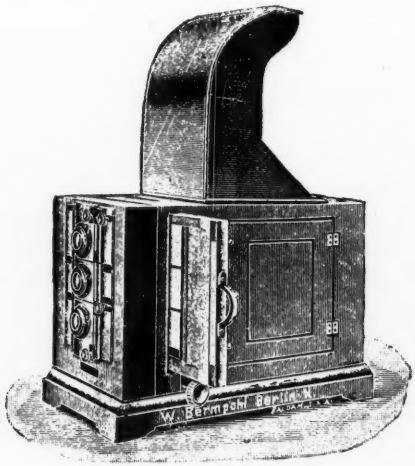

Figure 8.—Miethe Three-Color Projection Camera.

were taken—has been utilized by many inventors since the time of Maxwell. F. E. Ives was the first worker to obtain first-class results by this process. He made three negatives side by side on one plate in a repeating back

carrying the filters in front of the plate. A positive printed from this triple negative was then projected in a special triple projection lantern arranged so that the three images could be made to coincide upon the screen (see Figure 6). With this apparatus very beautiful results were produced by Ives, who also designed a number of special cameras for the purpose of taking the three records simultaneously. Professor Miethe in Berlin again exploited this process. He used a triple projection lantern consisting essentially of three lanterns, one over the other, like an old-fashioned triple lantern, the negatives being taken on one plate which was allowed to fall on a repeating back, so that the negatives were one over the other (Figures 7 and 8), and from this plate a positive was printed which was put into the projection lantern. Lastly, Gaumont has used the process for three-color motion pictures, making the pictures very small, so that three pictures fall into the space of two ordinary cine pictures, and projecting them through a very ingenious triple lens.

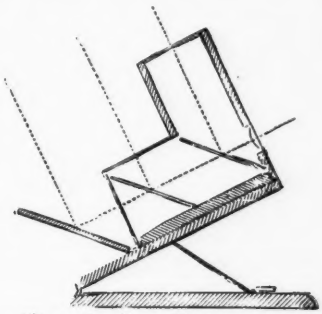

Figure 9 —Ives' Chromoscope.

The greatest objection to this process is that the pictures can be seen only when projected by a rather elaborate lantern. In order to overcome this objection, Ives designed his chromoscope, in which the three positives are placed over filters and their images are superimposed by means of mirrors, so that the three pictures can be observed simultaneously. This apparatus is shown in Figure 9.

The next article of this series will deal with the screen plate processes of color photography.

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**Iodine in Water Does Not Always Prevent Goiter.** Recent investigations abroad show that the widespread occurrence of goiter in a locality does not depend on the lack of iodine in the drinking water, as has been maintained heretofore. Samples of water from Aberdeen, Scotland, which is not a goitrous area, were very low in iodine content, while the drinking water of Cumberland and Derbyshire, both bad goiter areas, was not low in iodine content. The investigations were made by Dr. J. B. Orr, W. Godden, and J. M. Dundas of the Rowett Research Institute, Aberdeen.

These investigators state that in England there is no correlation between the presence of goiter and low iodine content of drinking water. This opinion is in direct contradiction to the theory commonly held, and supported by the fact that Switzerland and certain parts of the United States, where the iodine content of the water is low, have a large amount of goiter. An American investigator, Dr. R. Oleson, arrived at a similar conclusion after studying the effects of adding iodine to public water supplies. —*Science Service*

# THE CHEMISTRY OF THE RED AND BLUE PIGMENTS OF FLOWERS AND FRUITS. PART I

ERNEST H. HUNTRESS, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASSACHUSETTS

The coloring matters of natural substances have always interested chemists. In cases like indigo and alizarine where by virtue of their accessibility and durability the plant pigments could be utilized for dyeing purposes, the practical value of the substances became so great that almost as soon as a structural theory of organic chemistry had been developed, their chemical constitutions were determined and the materials synthesized. In many other instances, such as the coloring matters of many flowers and fruits which could never be produced in large enough quantity to serve as useful dyes, and where the presence of accompanying substances seriously interfered with the separation of the essential principle, or in which the complexity of this principle impeded the progress of efforts to determine its structure, a precise knowledge of their chemistry has been acquired only in recent years.

This does not mean that the subject has failed to attract attention. As long ago as 1664 Robert Boyle published a report on "Experiments and Considerations Touching Colours" in which he examined the color changes which take place when extracts from flowers are treated with acids and alkalies. Many other investigators have studied the subject since then and it has become evident that in a general way the pigments of yellow flowers constitute one class of substances, distinct in chemical character from those of the red and blue flowers which, together, constitute another. The chemistry of the yellow pigments has been well established for some years but real understanding of the second group is quite recent. It is not within the scope of this account to relate the vicissitudes encountered by the many workers in this field prior to 1913: a complete resumé of such progress as they made can be found in Perkin and Everest's "Natural Organic Colouring Matters." During the last fifteen years, however, remarkable strides in this field have been made by Willstätter, Karrer, and Robinson. In a remarkable series of investigations carried out at the Kaiser Wilhelm Institute of Dahlem, Berlin, Richard Willstätter laid the foundations for effective progress in a work so masterly that it received the Nobel prize in chemistry in 1915. Through the efforts of P. Karrer and his students at the *Technische Hochschule* at Zürich, this fundamental work of Willstätter's has been greatly extended and clarified. Both of these men have attacked the problem from the analytical side, first isolating the essential chromatic principle and then effecting a determination of its structure by breaking it up into smaller recognizable fragments. Robert Robinson, at the University of Manchester, England, has meanwhile

been developing a synthetic technic whose ultimate objective is the synthesis of substances identical with the natural red and blue pigments isolated and identified by Willstätter and Karrer.

The work of all these men is of fascinating interest and incalculable value. Nevertheless so much has been accomplished and the names and formulas of the substances involved appear so forbidding to the uninitiated that many persons who have not followed the work from the beginning are swamped by its apparent complexity. Furthermore, the original papers are reported in three different foreign publications, which may not easily be accessible to all and which, aside from the natural consequence that all save Robinson's work is in German, necessarily include a great deal of highly interesting but somewhat confusing detail. It is the purpose of the present paper briefly to review the accomplishments of Willstätter, Karrer, and Robinson in such an elementary way that a general conception of the present status of our knowledge of the red and blue natural coloring matters of fruits and flowers may be obtained.

## The Anthocyanins

The term "anthocyan" comes from two Greek roots signifying, respectively, "flower" and "blue," and was introduced by Marquart in 1835 to designate the blue pigments of flowers. We retain other more common uses of one of these roots in "anthology"—a collection of flowers of literature, *i. e.*, a selection of poems: and in "anthomania"—an extravagant fondness for flowers. Gradually the belief developed that the red and blue flower pigments were merely different forms of the same substances and that their different colors were due to variation in the character of the cell sap; this resulted in the extension of the term "anthocyan" to all pigments of this group. When it became apparent that in the plant these pigments were combined with sugars and thus occurred as glucosides, the ending "in" was attached to the word to emphasize this chemical classification. It is now apparent that the individual anthocyanins contain similar nuclei and that the wide variation in color is due to slight alterations in the molecule which do not affect the main skeleton. Thus the anthocyanins have come to be regarded as a chemical class in the same way as the proteins, fats, or carbohydrates.

The anthocyanins are all glucosides and occur as such in the plant cells. They are easily soluble in water or alcohol but insoluble in other organic solvents such as ether or chloroform. For this reason they cannot be extracted from the flowers by means of volatile solvents and special means of separation from the accompanying water-soluble salts and sugars had to be devised. The anthocyanins are all amphoteric, however, and form salts either with acids or bases. The salts with acids are particularly well crystallized and all the anthocyanins have been isolated by processes in

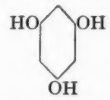
which, after extraction of the crude pigment and removal of accompanying impurities, the essential principle has been isolated in the form of its salt with hydrochloric acid or occasionally with picric acid. The stable salt formation is in marked contrast to the behavior of the yellow plant pigments of the flavone and flavonol groups whose salts are easily dissociated in solution. It is even more remarkable in view of the fact that the anthocyanins contain no basic nitrogen atom and that these addition products are oxonium salts formed by addition of acid to a divalent oxygen. Despite the quadrivalent oxygen atom the salts are so stable that in many cases they can be heated at 100° without loss of hydrogen chloride.

From the structural viewpoint the two most important chemical reactions of the anthocyanins are those with boiling dilute hydrochloric acid and with fused alkalies. Although some twenty-eight definitely characterized anthocyanins have now been isolated, it was found in every case that upon boiling for a few moments with 20% (6*N*) hydrochloric acid the substance was completely hydrolyzed into two components: one a sugar, either glucose, galactose, or rhamnose; the other a sugar-free pigment, hereinafter called an anthocyanidine. According to whether one or two molecules of sugar were found for each molecule of sugar-free pigment, the original anthocyanins are classified into monoglucosides or diglucosides. From a few anthocyanins there was obtained in addition to the carbohydrate and anthocyanidine, one or two molecules of some organic acid, either malonic, *p*-hydroxybenzoic, or *p*-hydroxycinnamic acid in the cases so far discovered. The behavior of the anthocyanin with fused caustic alkali is the same as that of the anthocyanidines presently to be discussed.

The sugar-free pigment thus obtained by acid hydrolysis of each anthocyanin proved to be the real key to the study of their structure. It was found that each anthocyanidine much resembled its parent in general behavior: each formed crystalline salts with acids, gave characteristic colorations with ferric chloride, etc. Moreover, it developed that although the many different individual anthocyanins gave on hydrolysis various kinds or numbers of carbohydrate molecules, the sugar-free pigment obtained was often the same. In fact, from one group of twenty-one different anthocyanins from a wide variety of flowers and fruits, only three different anthocyanidines were obtained and these three proved to differ one from the other only by a single atom of oxygen. Furthermore, the anthocyanidines obtained from the remaining group of seven anthocyanins proved to be merely methyl or dimethyl ethers of these three fundamental sugar-free pigments. Every anthocyanin, therefore, is a compound of an anthocyanidine with one or two molecules of a simple sugar. In a few cases these are also combined with an organic acid, though this is not an essential characteristic. Upon hydrolysis these various components may again be separated.

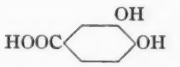
## The Anthocyanidines

*The Structure of the Three Fundamental Anthocyanidines.*—The structure of these three fundamental anthocyanidines, to which reference has just been made, was deduced by Willstätter from the behavior of their chlorides on fusion with sodium hydroxide. Under the degradative action of such treatment each anthocyanidine breaks up into two simpler products, one of which is a phenol, the other a phenol carboxylic acid. The phenol obtained from each of the three homologous anthocyanidines is the same, phloroglucinol (1,3,5-trihydroxy-benzene) (I). The phenol carboxylic acid obtained from the simplest anthocyanidine is *p*-hydroxybenzoic acid

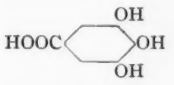



Phloroglucinol
(I)

*p*-Hydroxybenzoic acid
(II)

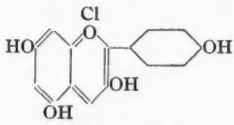



Protocatechuic acid
(III)

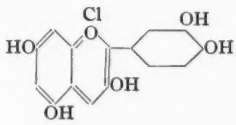



Gallic acid
(IV)

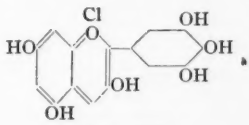
(II), that from the next simplest is 3,4-dihydroxybenzoic acid or protocatechuic acid (III), that from the third is 3,4,5-trihydroxybenzoic acid or gallic acid (IV). From these observations and the composition of the anthocyanidine chlorides found by analysis, it was not a long step to deduce the actual structure of the original materials. The simplest was named pelargonidine (V) because it was first obtained from the anthocyanin found in the scarlet pelargonium: the next homolog, isolated from the pigment of the rose, was the first anthocyanidine to be obtained and received the name cyanidine (VI): the highest homolog was obtained from the anthocyanin from larkspur, otherwise known as delphinium, and so received the name delphinidine (VII). They are conveniently represented in the form of their chlorides.




$C_{15}H_{10}O_5$. HCl
Pelargonidine chloride
(V)

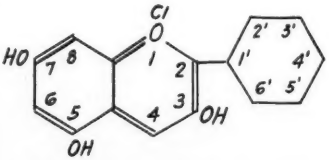



$C_{15}H_{10}O_6$. HCl
Cyanidine chloride
(VI)

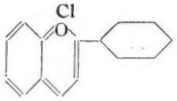



$C_{15}H_{10}O_7$. HCl
Delphinidine chloride
(VII)

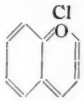
While considered separately it might seem that any of these substances represents a fairly complicated organic molecule, yet inspection of the group shows that the three anthocyanidines are respectively mono-, di-, and tri-hydroxy derivatives of a single simpler structural unit. This unit bears the name of 3,5,7-trihydroxyflavylium chloride (VIII)




3,5,7-Trihydroxyflavylium chloride
(VIII)




Flavylium chloride
(2-phenylbenzopyrylium chloride)
(IX)



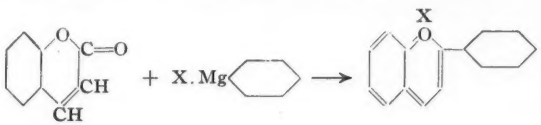

Benzopyrylium chloride
(X)

and is itself a substitution product of flavylium chloride (IX). The fundamental parent substance of the entire family is benzopyrylium chloride (X) which has been thoroughly studied as a result of the work of Decker and Fellenburg beginning in 1908. This group of anthocyanidines (V, VI, VII), therefore, forms an homologous series where each individual contains one more hydroxyl in the position 2 phenyl group than did the next preceding. It is plain that upon disruption of the substances during alkali fusion the phloroglucinol obtained in each case comes from the left half of the molecule (which is alike for all): the substituted phenyl group gives rise to the series of hydroxybenzoic acids whose isolation has already been noted.

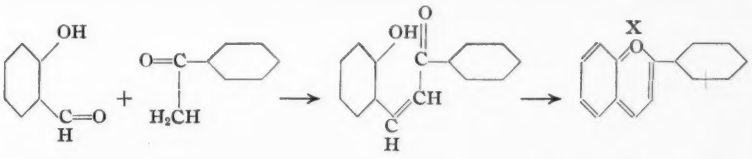
*The Synthesis of the Three Fundamental Anthocyanidines.*—It is of interest to note at this point that the constitutions thus assigned to these three anthocyanidines by degradative processes have since been brilliantly confirmed by synthesis. Since such syntheses have been independently carried out by entirely different methods in the laboratories of Willstätter in Germany and Robinson in England, and since both the resultant products are identical with the natural material (Ref. 1), there no longer seems room for reasonable doubt as to the validity of the assigned formulas. It is very important to note that these syntheses refer to the several anthocyanidines and not to the glucosidic anthocyanins themselves. Progress toward their synthesis will be mentioned later.

The syntheses of pelargonidine, cyanidine, and delphinidine have been approached through the two general methods suggested by the classical work of Decker and Fellenberg for the preparation of benzopyrylium derivatives. These two methods may be summarized briefly as follows:

(1) The addition of aryl Grignard reagents to coumarins.



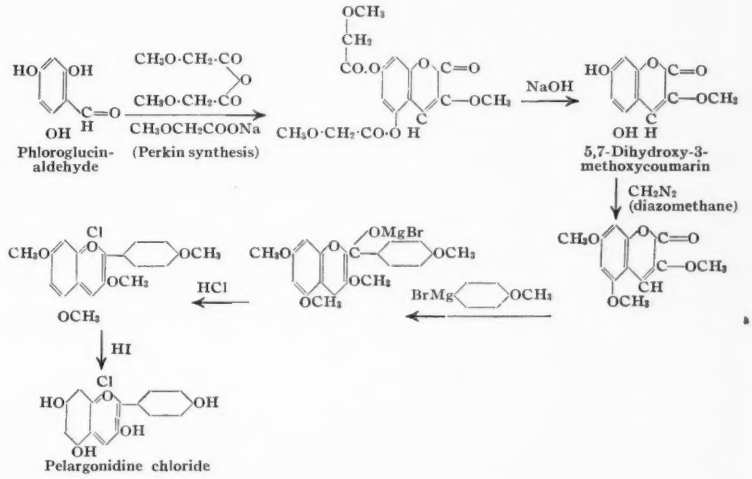

(2) The condensation of *o*-hydroxybenzaldehydes with appropriate ketones followed by ring closure.



The first of these general procedures has been used by Willstätter, the second by Robinson.

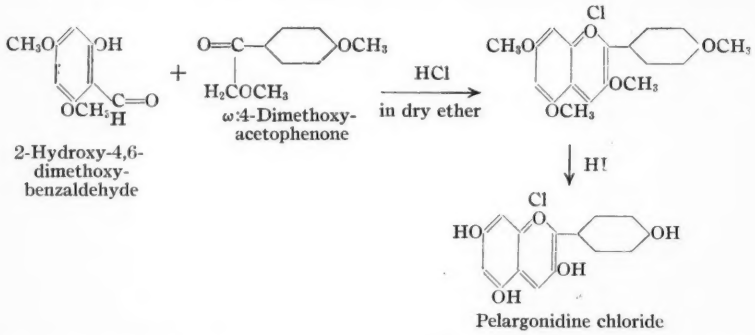
The first anthocyanidine to be prepared was pelargonidine whose synthesis was reported by Willstätter at a meeting of the Prussian Academy of Sciences on July 30, 1914, only a few days prior to the outbreak of the war. The next was cyanidine, reported to the Baeyer Academy of Sciences and the Chemical Society at Munich in 1920. A formal report of the details of these experiments did not appear until 1924 (Ref. 2). Meantime Robinson's experiments had been going on and his independent synthesis of pelargonidine reported in 1924 (Ref. 3) was rapidly followed by that of cyanidine and delphinidine in the following year (Ref. 4). In 1926 the preparation of synthetic pelargonidine was achieved again (Ref. 5) in a somewhat different way.

Willstätter's synthesis of pelargonidine may be indicated as follows:




By substituting for *p*-anisyl magnesium bromide the corresponding veratryl magnesium iodide the synthesis was extended to cyanidine.

Robinson's synthesis of pelargonidine may be even more easily represented.




These syntheses all seem simple on paper but the preparation of the starting materials and the execution of the several steps represent skill and patience of the highest order.

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(2) Willstätter, Zechmeister, and Kindler, "The Synthesis of Pelargonidine and Cyanidine," *Ber.*, **57**, 1938–44 (1924).

(3) Pratt and Robinson, "A New Synthesis of Pelargonidine Chloride," *J. Chem. Soc.*, **125**, 188–99 (1924).

(4) Pratt and Robinson, "Pyrylium Series V. A Synthesis of Cyanidine Chloride and Delphinidine Chloride," *J. Chem. Soc.*, **127**, 167–75 (1925).

(5) Nolan, Pratt, and Robinson, "Pyrylium Series XI. A Synthesis of Peonidine Chloride (and Pelargonidine Chloride)," *J. Chem. Soc.*, **1926**, 1968–71 (1926).

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**Sugar Factory Waste Suffocates Fish.** Wanted: a way to keep beet sugar factories from smothering fish.

This is not just another nonsense sentence, but a serious problem in industrial chemistry. For one of the most difficult classes of industrial waste to handle is the waste liquor from beet sugar factories. It contains easily fermentable sugar and other carbohydrates, and the bacteria feeding on these substances use up all the oxygen in the water, so that the poor fish have nothing to breathe. They are not poisoned by this factory waste, but suffocated.

At the great Rothamsted Experimental Station near London, bacteriologists are devoting much research toward the finding of ways to free sugar factory waste from most of its fermentable materials before discharging it into the rivers. Two methods that look promising involve holding the liquor in tanks or cisterns and speeding up the fermentation process to completion before discharge. A third, which seems to be the best, consists of a percolating filtration, which has given a purification of 95 per cent, measured on the basis of oxygen absorption. Actual trials at a beet sugar factory indicate that the method has promise, although certain mechanical difficulties still have to be overcome.—*Science Service*

# CARBOLOY—A NEW TOOL MATERIAL

GUY BARTLETT, GENERAL ELECTRIC COMPANY, SCHENECTADY, NEW YORK

Tungsten carbide, an extremely hard but brittle material, has been combined with cobalt, a tough and strong metal, to produce the hardest cutting material yet developed in a research laboratory. One would not think of cutting a screw thread in a glass rod with the usual tool-steel cutter—but it can be done with the new material. The only way in which a hole could be actually bored through concrete has been with a diamond drill, although, of course, it has been possible to make a hole in rock with the noisy "star" hammer; but the new material has made it possible to drill through concrete without expensive diamond-tipped equipment. Glazed porcelain is another example of a material that cannot be handled with tool-steel cutters, but it succumbs to a tool made of tungsten carbide and cobalt.

STARTING TO CUT GLASS ROD WITH CARBOLOY

Strange as it may seem, there are materials soft enough to be whittled with a pocket knife, and yet so abrasive that tool-steel cutters are dulled quickly and rendered useless. Genelite, composed of copper, tin, and carbon, is such a substance; and hard rubber, molded compounds such as Bakelite, and mica likewise spoil tool edges quickly. There are hard steels that cannot be handled with tool-steel cutters, some not being cut at all and others with difficulty, and here again the new cutter shows its superiority. And even though the tip of the new cutter should become heated to a bright red—a temperature that would be disastrous to its predecessors—it continues calmly with its work, for the material has no temper.

The new material, named carboloy, was announced by Dr. S. L. Hoyt of the Research Laboratory of the General Electric Company at the annual convention of the American Society for Steel Treating held at Philadelphia, October 11, 1928.

## Its Physical Properties

That carboloy is a hard material is amply shown by window panes in the laboratory rooms, for deep scratches have been made in the glass with the material. And not only glass but natural sapphire, next below diamond in the scale of hardness, can be scratched with carboloy. If held against

the side of an emery grinding wheel, a carboloy cutter will wear a deep, narrow groove into the stone, whereas the usual tool materials would be worn away by such treatment. In the course of laboratory determinations of the properties of carboloy it was found that the usual method of using the Rockwell test for quantitatively obtaining the hardness of the material

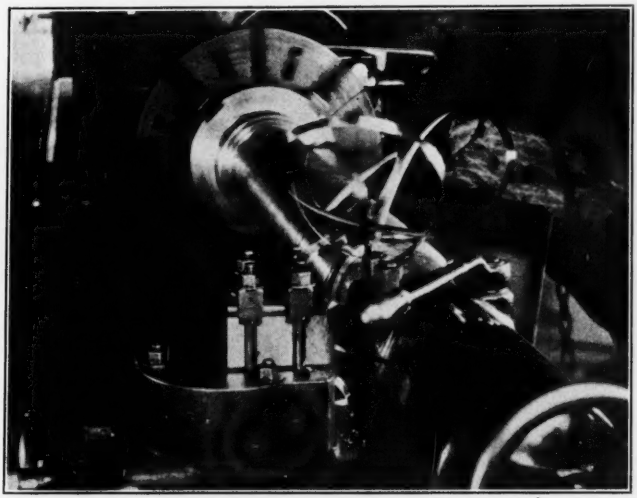
Dr. S. L. Hoyt, Research Laboratory, General Electric Company, holding in his left hand a piece of Bakelite with metal insert and a piece of glazed porcelain, both of which were cut with carboloy. On the table and in his right hand are representative carboloy tools.

could not be employed—the point of the diamond wore and crumbled in too short a time if the diamond penetrator was loaded with a weight. It was necessary to use the penetrator without a load. The test showed that common hardened tool steel has an average maximum hardness of 850 of the Brinnell scale, that the hardest steel may be taken as about 1000, and

that the hardness of carboloy runs 2000 and above. Tungsten carbide without cobalt has a strength of less than 50,000 pounds per square inch. The addition of cobalt increases the strength of the material to more than half that of high-speed steel, carboloy having a strength of 275,000 pounds, and quenched and tempered high-speed steel 425,000 pounds.

Wide and Deep Groove Cut in Glass with Carboloy

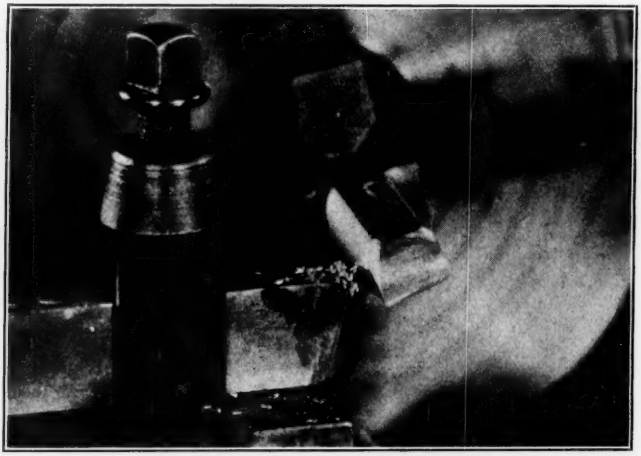
Toughness is an equally important property when considering cutting materials. The new material will withstand severe blows of a soft peen on the edge of a bar, and the edge does not crumble even though the supporting block of copper shows marked indentations as a result of the blows from the peen. The ability of carboloy to make intermittent cuts on metals further attests its strength and toughness.



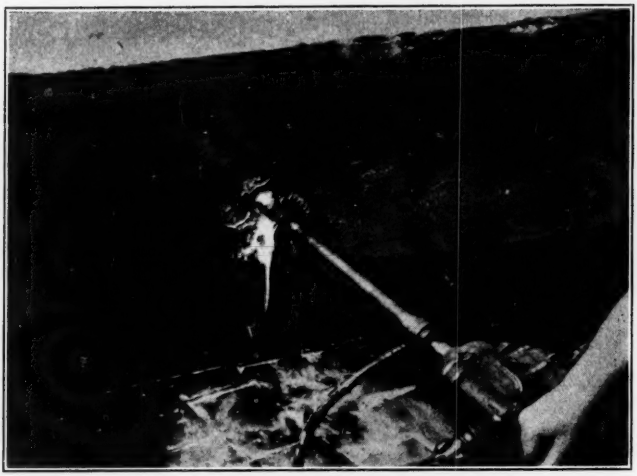
Cutting Nickel Steel Test Log with Carboloy

Since carboloy has no temper to be "drawn" by the heat generated during cutting operations and since it is much harder than the materials

machined, even at elevated temperatures, it has a distinct advantage over steel tools, which are frequently softer than the machined materials and



CUTTING A HIGH-SPEED CUTTER WITH CARBOLOY



CARBOLOY CONCRETE DRILL IN USE

which cannot be used at elevated temperatures. Cutting nickel steel when the point of the carboloy tool was at a bright red heat was effected

without the tool showing any ill effects. The tungsten carbide material does not pit or tarnish, and is dissolved in acids only with great difficulty. When cutting metals at the speeds usually employed, the moderate temperatures have not been observed to be harmful. If the speed of operation

CARBOLOY CONCRETE DRILL

Showing tip. Showing core of concrete.

EFFECT OF NICKEL STEEL TEST LOG ON CUTTERS

Upper—Carboloy tool, undamaged. Lower—High-speed steel cutter, showing burned edge.

is too high and the abrasion is severe, small particles of carbide may oxidize and shoot off from the edge as sparks. The temperatures ordinarily involved simply produce temper colors, however, much the same as with high-speed steels.

### Tests with Iron and Steel

It is customary to use a nickel steel test log, operating at about 50 feet per minute, in testing high-speed tool-steel cutters. Because of the lack of effect on the new cutter, however, it was necessary to increase the speed to 200 feet per minute. At this higher speed the steel cutter failed in 16 seconds, with its edge burned off. The tungsten carbide tool, operated under identical conditions, was run for an hour before the test was arbitrarily stopped, and the tool was still cutting and capable of cutting for a much longer period of time. In another run with a test log of chromium-nickel steel, with a cut of $^3/_8$-inch and a feed of $^1/_8$-inch, good high-speed tools failed in from six to eight minutes when operated at 35 feet per minute. Carboloy tools, with the same cut and feed but at 70 feet per minute, twice the speed, showed but little wear after 10 minutes.

Hadfield's manganese steel, previously in the non-machinable class of metals, has been found to yield so easily to the new cutter that commercial operation is expected to be developed. Similarly, in the General Electric research laboratory, it has been found that numerous experimental alloys can be handled with tungsten carbide cutters, although not with the usual tools. It has also been found that even a block of quenched high-speed steel can be machined on the shaper with the new material, although with difficulty, and that the same holds true with the super high-speed cobalt-chromium alloys.

When considering cast iron, cutting conditions are unique. The parts are frequently large, the cutting speeds are lower, the cuts are heavier, and the tool pressures greater. One of the most difficult jobs with cast iron has been the removal of the surface layer of chilled metal, particularly if the surface contains sand. The chilled iron and sand are harder than tool steel, so the edge of the cutter is taken off almost at once. Tungsten carbide, however, is harder than the surface of the cast iron and it can handle work of this kind without difficulty. In fact, the same speeds and feeds can generally be used for the surface as for the sub-surface cuts.

Hard castings can be handled as easily as soft ones with the new material; and intermittent cuts are also handled satisfactorily.

### Tests with Special Materials

Mention has already been made of some of the unusual work performed by the new cutter, such as handling glass, concrete, porcelain, and molded compounds. One difficulty with today's tools has been that wear of the tool causes a taper. In machining a hollow cylinder of carbon, for instance, the best tool steel loses its cutting edge and begins cutting a taper soon after starting; tungsten carbide tools take an entire cut without tool wear, and hence without tapering.

Genelite, composed of copper, tin, and carbon, is so soft it can be whittled easily with a knife, but it is also so abrasive that it dulls a steel tool almost at once. A cut on a small cylinder of only a few inches in length has always been on a taper; here again the tungsten carbide tools have not been worn, and hence the cuts are not tapered. The bearing surfaces of commutators of electric motors, of alternate layers of mica and copper, have always presented a problem since they must be accurately machined and since mica is very abrasive. Here also the new material gives a smooth finish without undue wear. Molded compounds, such as Bakelite and hard rubber, likewise wear tools quickly. Diamond tools have been used with Bakelite because heretofore these stones have been the only material that would stand up at the high cutting speeds used. If the Bakelite contained a metal insert, however, a special operation was needed since the diamond would be broken if it struck the metal at high speed. With carboloy no special operation is required.

### Its Possibilities

In his talk at the convention of the American Society for Steel Treating, Dr. Hoyt indicated the possibilities of the new tool material in his references to experiments conducted with molded materials containing metal inserts, such as fabric gears used in automobiles. Cobalt-chromium alloy cutters, which had given the best previous service in this work, required redressing for every 150 parts machined; the new tungsten carbide tools, operating under identical conditions, finished 11,000 parts before they required sharpening.

"The peculiar virtues of tungsten carbide promise to make it the dominant tool material in the field of weak or 'low tensile' materials, which are also uncommonly abrasive to present tools. Here the durability of carboloy tools has been found to be of the order of 25 to 75 times that of high-speed tools," Dr. Hoyt said. "The new material can machine harder and denser grades of steel than can be handled economically by high-speed steel; and steels with higher alloy contents than are now commercially machinable will be brought into the machinable class."

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**Plants "Sunburned" by Ultra-Violet Rays.** Plants no less than people can get a browned epidermis by exposure to ultra-violet rays, it was disclosed before the section on botany of the British Association for the Advancement of Science at its recent meeting in Glasgow. The effects of these invisible rays on plants have been investigated by a committee of British botanists, which reported through its secretary, Dr. E. M. Delf. Exposure to the glare of a quartz mercury vapor arc, Dr. Delf stated, caused browning on the plants' skin, which on microscopic examination was found to be associated with a breakdown of the outer layers of cells. The investigations are being continued this year.—*Science Service*

# EVENING INSTRUCTION FOR THE CHEMIST IN INDUSTRY. THE CHICAGO PLAN*

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The increasing demand of the industrial world for chemists having graduate training has caused a larger appreciation of the advantages of such training among those who are already employed by day and who, perhaps, are no longer in a position to return to daytime study in college or university. They wish to keep abreast of the developing science and to move forward at least in step with the more recent graduates who have had the advantages of a broader training. And, while there have been opportunities for evening study of the usual undergraduate courses, there has been until recent years but small opportunity for graduate instruction in chemistry and the allied sciences in the evening.

In Chicago, a movement to supply this need has been in operation since 1923, with ever-increasing success. A description of the development of this movement has been published previously,[1] and also a survey of the types of students enrolled in these courses, their interests and their response to the instruction offered.[2] Other sections of the American Chemical Society are now evidencing interest in developing similar courses, and the Chicago Committee on Evening Courses will be glad to assist any sections which are contemplating such work. This paper is intended to explain the methods used in establishing these courses, the growth of the movement, and some characteristics of the classes.

Any description of the work naturally divides itself into two parts. The first period lasted from the spring of 1923 until the winter of 1925–26. The second period began about the first of 1926 when the movement was officially recognized by the Chicago Section, A. C. S., and when coöperation with the University of Chicago became an essential part of the plan. The movement was initiated when a group of about twenty chemists were called together to attend a series of lectures on physical chemistry under Dr. W. V. Evans. At the close of this course, it was recognized that this plan was of too great value to be allowed to lapse; so a few members of the group set about to continue and to enlarge the plan. This self-appointed committee has continued to be the nucleus of those who have carried on the work. During the five years in which courses have been given the committee has called in additional members from time to time and no less than twenty-five or thirty have contributed their counsel. To

* Read before the Division of Chemical Education of the American Chemical Society at St. Louis, April 18, 1928.

[1] A. Guillaudeu, *Chem. & Met. Eng.*, **33**, 474 (1926).

[2] W. A. Noyes, Jr., THIS JOURNAL, **4**, 969–72 (Aug., 1927).

organize the second and the succeeding courses before the committee had any connection with the A. C. S. or the University of Chicago, the general plan was to call a meeting of all those who were interested in securing instruction, regardless of their particular interest, and to ask in what subjects they wished to be taught. To the information so obtained was added all that could be gathered in personal conversations with as many chemists as possible. Then the committee, acting on these suggestions, would seek to find instructors who could and would teach these subjects in the evenings, and would make tentative arrangements with them as to hours, dates, remuneration, the subject matter of the proposed courses, etc.

Another meeting of all who were interested was then called, the possible arrangements were explained, and an attempt was made to get the full coöperation of all present so as to have as large a support as possible for the class, or classes, which were desired by the largest number. Taking the vote by a show of hands seemed to arouse in the individual a feeling that he had a personal interest in the establishment of the work. Most chemists recognized the need on their part of instruction in more than one subject and were willing to study these in such order as could be conveniently arranged. A desire to coöperate was quite generally manifested.

As to the compensation of the instructor, it was soon found that the better plan was to pay him a fixed fee of $240 per twelve lectures of two hours each and to pro-rate this charge among the students rather than to charge the students a fixed fee and to be unable to make a guarantee to the instructor. The use of a room as a meeting place was donated by the Chicago Chemists' Club; the committee assumed its own expenses; and thus the only expense to the student was the pro-rated share of the instructor's fee. The officers of the Chicago Section, A. C. S., were indulgent and allowed the plans of the committee to be presented to the local chemists both verbally at the regular meetings and also through notices in the *Chemical Bulletin*. The coöperation of other groups was sought, including the medical, dental, pharmacal, and engineering professions, the steel treaters, etc. The medical profession contributed students to several classes, but the others were only mildly interested. Of all these means of advertising, the most effective was the personal conversation; next, the printed notice in the *Chemical Bulletin*.

Several canvasses were made to determine the most acceptable evening and hour for meeting. These always resulted in showing Monday as the preferred evening, followed by Wednesday, Tuesday, and Thursday. Friday and Saturday evenings were strictly tabooed. No matter what hour was chosen it worked a slight hardship on some; the preferred time was from 7.00 to 9.00 P.M. Each course met but once a week. Some students would attend two courses meeting on Monday and Wednesday.

In as much as these classes were not given by any college or university it was not possible for the student to obtain credit for the work done, and, correspondingly, there was no examination, nor was there any set prerequisite, nor any required study. But these were no great disadvantages, for the courses were taken by those who were seeking information for their own advancement, and each made such preparation as suited his time and his purpose. As attendance on these courses was dictated only by the desires of the individual and as there were no prerequisites, the groups were quite heterogeneous. Some classes contained holders of the Ph.D. degree along with others who had not advanced beyond sophomore work. The average age was probably in the neighborhood of 32 to 35 years, but there were wide variations in age. Besides these contrasts, there were large differences in the industrial connections and experiences. All of these things made more difficult the task of the instructors, but the problems were largely counterbalanced by the greater maturity and earnestness of the students.

Under these conditions seven courses were given during two and one-half years. Of these, four dealt with physical chemistry, one with the chemistry of colloids, and two with biological chemistry. The collective enrolment was 140. The number of individuals was over 80. The number in the separate classes ranged from 14 to 29. The statistics of the classes will be discussed hereafter at greater length.

By this time the continued interest in the courses had proved that there was a steady and a rather insistent demand for such instruction and that the student could gain considerable from them in spite of the obvious disadvantages. But to obtain the best results and to do the greatest good it was advisable to bring the work into close coöperation with a recognized institution of learning. This would allow the student to obtain college credit for his work, to apply this credit toward a degree, and to establish connections with the university faculty. It would allow the work of the committee to be systematized, and it would allow the scope of the courses to be broadened. Consequently, the committee sought and obtained two things: first, to be appointed as one of the committees of the Chicago Section; second, to establish a firm connection with one of the local universities. By the first of these, the courses ceased to be the product of a few individuals and they were now sponsored by a large and representative group. This endorsement of the work added much to the strength of the movement. By the plan of coöperation with the University of Chicago there were gained all of the usual advantages of such a connection except that most of the students are prevented, by the hours of their employment, from making use of the library and the laboratory facilities and from enjoying that intimate friendship with the instructors which is one of the chief advantages of daytime classes.

One of the Colleges of the University of Chicago is known as University College, which is a down-town branch of the University of Chicago and caters to students that cannot take work on the campus. With this College very desirable arrangements were made. We might summarize these by saying that the committee of the Chicago Section, A. C. S., endeavors to learn in what subjects instruction is particularly wanted and which instructors are considered satisfactory for the purpose. These data are then brought before the Dean of University College, who ascertains when and by whom the desired subjects can be taught, and arranges for the courses to be given. Subsequently, the committee gives as much publicity to the program as can well be done through announcements at the regular meetings of the Section and by notices in the *Bulletin*. Besides this, the College sends to each member of the Chicago Section a copy of its announcement of the work in chemistry for the ensuing quarter. University College then conducts the course as it does any other regularly scheduled course, registering the students, collecting the fees, furnishing the classroom, and giving University credit to those who fulfil the usual requirements. An essential part of the plan is that the instructors may be drawn not only from the faculty of the University of Chicago, but also from other schools and from the industries. Several members of the faculty of Northwestern University are now upon the list.

Under this new arrangement the first course was given in the spring of 1926. Dr. Stieglitz gave six lectures on the application to organic chemistry of the electronic theory of valence; and Dr. Harkins gave six on various topics of physical chemistry. The enrolment of 79 far surpassed all expectations, for the largest previous class had been but 29. Beyond question, the high esteem in which these lecturers are held and the unusual opportunity to hear them in a series of lectures, instead of in only a single brief one, aided materially in attracting so large a number.

Toward the close of this class a questionnaire was circulated among these students and also was issued to all members of the Chicago Section. A copy of it is given here together with a tabulation of the answers. It was answered by 126 individuals, or about one-sixth the membership of the Chicago Section.

## QUESTIONNAIRE

The Chicago Section of the American Chemical Society, through its committee, has launched successfully a series of evening lectures in chemistry. These are being given in coöperation with the University of Chicago by University College. The nature of such courses will be determined by requests from among the chemists. In order to plan for the coming year the committee desires to secure expressions of opinion from as many of those who are interested as possible. Will you kindly answer the following questions?

1. Please indicate the particular purpose you have in mind in taking such a course.

| | |
|---|---|
| Advanced college credit | 44 |
| General culture in chemistry | 63 |
| Specific information | 30 |
| Contact with university lecturers | 28 |

2. Would you be interested in a plan which would enable you to work toward an advanced degree in chemistry, such as the Master's or Doctor's degree?

| | |
|---|---|
| Yes | 68 |
| No | 26 |

3. Do you prefer broad fundamental courses, such as physical chemistry or organic chemistry?

| | |
|---|---|
| Yes | 70 |
| No | 22 |

4. Or do you prefer specialized courses, such as food chemistry, chemistry of iron and steel, the sugars, etc.?

| | |
|---|---|
| Yes | 37 |
| No | 32 |

5. Would you like to have courses in related subjects such as:

| | |
|---|---|
| Physics | 40 |
| Mathematics | 33 |
| Physiology | 12 |
| Geology | 19 |

6. Do you desire instruction in chemical engineering?

| | |
|---|---|
| Yes | 46 |
| No | 36 |

7. Is there any particular lecturer in Chicago whom you would like to have give courses in chemistry?

Forty-three votes were distributed among eight men.

| | |
|---|---|
| No | 33 |

8. Supposing that the following or similar courses could be arranged and one or two of them given next fall, winter, and spring (if the enrolment were sufficient), would you expect to enrol? These courses are listed as examples only. In which course or courses?

(*a*) Advanced inorganic chemistry. A series of half-major lecture courses; the groups of the periodic system; thermal analysis; alloys; coördination theory, etc.

(*b*) Theories underlying analytical chemistry. Precipitation; oxidation; reduction; electrometric titrations, etc.

(*c*) Organic preparations. Laboratory work in the evenings.

(*d*) Colloid chemistry.

Answers were: (*a*) 19; (*b*) 31; (*c*) 16; (*d*) 42.

9. If your desired course is not listed above, please indicate the nature of it here.

Thirty-four topics were mentioned, receiving from one to four votes each. These topics represent branches of the main divisions of chemistry and we may classify the votes as for

| | |
|---|---|
| Physical chemistry | 11 |
| Industrial chemistry | 6 |

| | |
|---|---|
| Organic chemistry | 6 |
| Metallurgy | 5 |
| Miscellaneous | 7 |
| Other sciences | 5 |

The tabulated answers show how generally the chemist who has been in industry for a few years appreciates the importance of a broad fundamental training and the understanding of the sciences other than chemistry. They also show how diverse are the interests of such a group.

We have found that all such votes must be considered as indicative, rather than as definite. For instance, while the number asserting a preference for advanced inorganic chemistry was 19 and for theories underlying analytical chemistry was 31, yet when given, the former attracted 35 and the latter 16. On the other hand, instruction in colloids was asked by 42, which was quite close to the actual enrolment of 49. In some of the earlier classes, the number who would enrol would be practically the same as the number who had signified their interest in the course, although very few of the latter would actually enter the course. For a time this was a confusing occurrence but the committee learned to appraise the probable attendance by the number interested beforehand. Best estimates are made after many personal conversations with chemists of all ages and employments. Yet, today, it is not possible to forecast accurately the number who will enrol in a particular course.

Having considered the methods of arranging for and of giving the courses, let us now turn to some of the results accomplished. The courses thus far given are tabulated here:

| Subject | Instructor | Date | Enrolled |
|---|---|---|---|
| Physical chemistry | Evans | Spring 1923 | 19 |
| Physical chemistry | Evans | Fall 1923 | 14 |
| Colloids | Noyes, Jr. | Fall 1923 | 29 |
| Physical chemistry | Evans | Winter 1924 | 19 |
| Physical chemistry | Evans | Fall 1924 | 16 |
| Physiological chem. | Hanke | Spring 1925 | 24 |
| Physiological chem. | Hanke | Fall 1925 | 19 |

The above courses were given before, and the following courses after, the agreement to coöperate with the Chicago Section of the A. C. S. and the University of Chicago.

| | | | |
|---|---|---|---|
| Organic chemistry<br>Physical chemistry | Stieglitz<br>Harkins | Spring 1926 | 79 |
| Theories of anal. chem. | Noyes, Jr. | Fall 1926 | 16 |
| Math. for chemists | Young | Fall 1926 | 14 |
| Physics | Lemon | Winter 1927 | 20 |
| Adv. inorg. chemistry | Schlesinger | Winter 1927 | 31 |
| Physics | Lemon | Spring 1927 | 24 |
| Adv. inorg. chemistry | Schlesinger | Spring 1927 | 24 |

| | | | | |
|---|---|---|---|---|
| Physiological chem. | Hanke | Fall | 1927 | 38 |
| Colloids | Harkins | Fall | 1927 | 49 |
| Physical chemistry | Evans | Winter | 1928 | 39 |
| Physiological chem. | Hanke | Winter | 1928 | 38 |
| Physical chemistry | Evans | Spring | 1928 | 31 |
| Chem. of carbohydrates | Glattfeld | Spring | 1928 | 24 |

We do not have records of the industrial connections of all of the students; but the seventy-two individuals who were registered in the first six courses were recorded as having these interests:

| | |
|---|---|
| Food and food products | 13 |
| Metal working | 12 |
| Medical and allied | 11 |
| Mineral oils | 4 |
| Rubber | 3 |
| Paint | 3 |
| Heavy chemicals | 2 |
| Miscellaneous | 7 |
| Not listed | 17 |
| | 72 |

Of the seventy-nine who were in the class taught jointly by Drs. Stieglitz and Harkins, the largest groups may be classified as:

| | |
|---|---|
| Teachers | 11 |
| Western Electric Co. | 10 |
| Medical and allied | 7 |
| Metallurgical | 8 |

The other forty-three are of widely diversified interests.

Since the courses have been administered by the University of Chicago, 226 individuals have enrolled a total of 426 times. In the 13 classes so given, we find that

120 students registered for only one course
60 students registered for two courses
28 students registered for three courses
6 students registered for four courses
4 students registered for five courses
7 students registered for seven courses
1 student registered for nine courses
1 student registered for eleven courses

Since it has been possible to obtain university credit for work done in these courses, a very few "campus" students have availed themselves of the opportunity to attend evening classes rather than the daytime courses, probably because the subjects were offered only during the evening in those quarters. But the very great majority of those served by these

courses have been those who otherwise would have been without opportunity to hear these subjects taught.

The total enrolment, by school years, shows a satisfactory rate of increase:

| Year | Enrolment |
|---|---|
| 1922–23 | 19 |
| 1923–24 | 62 |
| 1924–25 | 40 |
| 1925–26 | 108 |
| 1926–27 | 129 |
| 1927–28 | 219 |

Differences in the demand for certain courses as compared with that for certain others will account for some of the variation. For instance, a course in colloids is always in demand and will swell the enrolment of the year in which it is given as compared with a more mathematical course. But the above record of the registration shows a consistent and rather remarkable upward trend in the number of registrants.

With the giving of the courses above listed, there is a constantly growing number who will be interested in, and prepared for, courses for which these first courses are prerequisites. Hence, we now feel that the time is at hand to enlarge our program. We are working to establish a three-year cycle of classes so arranged that the prerequisite course shall precede those courses for which it is a logical forerunner, and so that courses that are simultaneously given shall not conflict with each other. We feel that the attendance is now sufficiently great that three courses can be given in each quarter. The tentative schedule for the next three years is the following one:

| | | |
|---|---|---|
| 1928–29 | Thermodynamics | Three quarters |
| | Advanced organic chemistry | Three quarters |
| | The phase rule | One quarter |
| | History of chemistry | One quarter |
| | Structure of matter | One quarter |
| 1929–30 | Advanced inorganic chemistry | Three quarters |
| | Physiological chemistry | Two quarters |
| | Colloids | One quarter |
| | Theories of analytical chem. | One quarter |
| | The less common elements | One quarter |
| 1930–31 | Physical chemistry | Three quarters |
| | Electro-chemistry | One quarter |
| | The carbohydrates | One quarter |
| | Mathematics for chemists | One quarter |

The last of these, mathematics for chemists, is intended to be preparatory for the course in thermodynamics which would be scheduled for the following year.

Now, all of these are lecture courses, as have been all of the preceding ones. The chemist who is busy in industry all day is inclined to the belief that he has had enough laboratory work and that his need is for the underlying theory which will enable him to apply himself to more advanced problems and which will keep him in touch with the ever-increasing progress of his profession. At the same time, there is a very definite understanding between the committee and the University that if and when there is manifest a demand for laboratory work, the University will take steps to satisfy that demand. For this purpose, there is a plan that access may be had not only to the laboratories of the University of Chicago upon its Midway campus but also, if desirable, to those of Northwestern University, or of Lewis Institute, or perhaps to some other convenient point.

To summarize, the results of the firm establishment of the evening courses are evident in several directions:

**1.** The University of Chicago, Northwestern University, the Chicago Section of the A. C. S., and through the individual student, the industrial enterprises of this vicinity have been brought into close coöperation, to the advantage of each.

**2.** An increased appreciation of the assistance which the A. C. S. supplies to the individual chemist has brought a better feeling toward the A. C. S. and some increase in its membership.

**3.** To the industries there is the gain through the further training of their chemists.

**4.** And, for the individual, there is a much enlarged opportunity for self-advancement, as well as for a cultural study of his science.

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**Ultra-Violet Transmitting Windows Declared Useless in Schools.** Schoolrooms and offices should spend their money on outdoor sunparlors, rather than on the new windows that allow ultra-violet light to pass through, is the advice given by Dr. Walter H. Eddy of Columbia University at the recent meeting in Chicago of the American Public Health Association. In homes and apartments these windows would be a great mothers' helper, saving the mothers from some of the hours spent walking up and down with babies and sitting in the park watching small children while they get their daily dose of sunshine.

Dr. Eddy experimented with rats that were fed a diet that would result in rickets, unless they get enough sunlight to counteract it. These rats were placed in cages in front of the new windows at various distances and angles and for the same length of time. Only those rats directly in the path of the sunlight failed to develop rickets. Those that were more than a few feet away or next to the window but outside of the path of the sun's rays, developed the disease.

Apparently the windows do permit the ultra-violet rays to pass into the room, but they do not go far enough or in sufficient intensity to take the place of outdoor sunshine. For office workers and school children, a few minutes' walk at noon will be more beneficial than all day spent in a room with ultra-violet light transmitting windows.—*Science Service*

# A SURVEY OF CHEMISTRY TEACHING IN WISCONSIN HIGH SCHOOLS

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Many times we are confronted with the statement: "Chemistry is one of the most poorly taught subjects in the high-school curriculum." This statement challenged the attention and interest of the writer to such an extent that it was decided to conduct a survey of the conditions prevailing throughout the state. The primary purpose of the survey was to determine whether or not there existed some basis for the above statement. In order to secure data for this survey a questionnaire was formulated with three objectives in mind.

*First*, to determine the general conditions under which the subject of chemistry is offered in the high schools of the state of Wisconsin: the number of schools giving courses in chemistry, to what extent chemistry is a required subject, the percentage of students taking the subject of chemistry, the subjects other than chemistry taught by the chemistry teacher, and supervision of extra-curricular activities demanded of the chemistry teacher:

*Second*, to obtain data upon the training and experience of the chemistry teacher:

*Third*, to obtain the reaction of chemistry teachers on the place and importance of methods in the teaching of chemistry.

Since a knowledge of the problems confronting the teachers of chemistry could be best gained from the teachers themselves the following questionnaire was sent to the chemistry teachers of the state.

## Questionnaire to Chemistry Teachers of Wisconsin

Name of chemistry teacher.....
High school.....Number of students.....
Number of students in chemistry.....
Is chemistry an elective or required subject?.....
What subjects other than chemistry are you teaching?.....
What extra-curricular activities are you called upon to do?.....
From what school or schools have you graduated?.....
.....Degrees held.....
Was chemistry your major subject while in university, college or normal school?.....
Number of years given to the study of chemistry.....
Where?.....
Have you had a course in the teaching of chemistry?.....
Number of years you have taught chemistry.....Where?.....
In your first teaching position were you employed to teach chemistry primarily?.....
If not, what were you employed to do?.....
What phase of chemistry do you find the most difficult to teach?.....
What change would you suggest in your chemistry course which would have given you a more thorough preparation for the teaching of chemistry?.....

Do you favor any improvement in the study methods in chemistry?.....
Do you find that your students do not know how to study?.....
What problems, not already mentioned, have you been confronted with in the teaching of chemistry?.....

## General Conditions

**Number of Schools Offering Chemistry.**—In making a study of the general conditions which prevail in the teaching of chemistry in the high schools of the state let us first consider the question: How many schools offer the subject of chemistry? The total number of questionnaires sent out was 225, of which 127 were returned.

Of the high schools that replied, 56.69 per cent offer chemistry. However, this figure cannot be considered as representative of the entire state for the reason that the questionnaire was sent only to the high schools with five or more teachers. If returns had been received from all the high schools the number offering chemistry would, no doubt, be less than fifty per cent.

**How Chemistry Is Offered.**—The second point of interest was to find the extent to which chemistry is offered as a required subject. The facts are tabulated below:

TABLE I

| How Offered | Number of Schools | Per cent |
|---|---|---|
| Elective | 55 | 76.4 |
| Optional with physics | 9 | 12.5 |
| Required[1] | 8 | 11.1 |

**Student Enrolment in Chemistry Courses.**—Now, let us turn to the facts in regard to the number of students enrolled in chemistry classes. Here we have a situation which to the writer seemed almost unbelievable but the facts tell their own story. Of the 45,931 total high-school enrolment, only 4686 (or 10.2%) are taking courses in chemistry.

**Teaching Load of Chemistry Teachers.**—Our next consideration was to find what subjects other than chemistry are being taught by the chemistry teachers of the state. The results of this study show that, of the 72 teachers represented, 17 are teaching chemistry only, while 55 are teaching additional subjects. The range of subjects taught by these fifty-five teachers offers an interesting situation. The subjects are listed below in the order of frequency in which they appeared on the questionnaires: Physics 32; General Science 21; Biology 9; Agriculture 6; Geometry 6; Physiology 4; Algebra 2; Ancient History 1; Civic Health 1; Latin 1; Civics 1; and Physical Training 1. In one school the teacher of

[1] In practically all of these eight schools chemistry was reported as required in the science courses but as an elective in other courses.

chemistry reported the teaching of Physics, Biology, Physiology, and General Science.

In connection with the teaching load there is a heavy demand made on the time and energy of the teacher in the supervision of extra-curricular activities. The variety of extra-curricular activities listed by the chemistry teachers follows.

Directors of Student Activities: Athletics, 20; School Annuals, 15; Dramatics, 7; Band, 3; Orchestra and School Paper, 1.

Advisers of Organizations: Science Club, 10; Radio Club, 2; Literary Society, 1; Technical Club, 1; Junior Class, 1; and Senior Class, 1.

The chemistry teachers in our high schools are confronted with another condition which no doubt causes the teaching of chemistry to be less efficient. This condition is indicated by the answer to the question: "In your first teaching position were you employed to teach chemistry?" While this is very largely an administrative problem, it indicates a condition which should be given very careful consideration. Some of the answers are indicative of the situation. "No—to teach eight high-school subjects, some of which I had never studied." "No—I was required to teach eleven hours of chemistry and twenty-one hours of physics." "No—physics, mathematics, football, basket-ball, and anything else that the others didn't want and the superintendent didn't know what to do with." "No—science, mathematics, physics, biology, physiology, and English grammar." "No—I did not teach chemistry the first year but taught six different subjects." "No—I taught chemistry, physics, general science, physical education, and coached." "No—I taught all the other sciences."

**Conclusions.**—The above data on the general conditions furnish facts upon which a few conclusions are drawn:

*First*, it is a regrettable fact that only ten per cent of our high schools are requiring the subject of chemistry. Does this not indicate that our high-school courses are composed too largely of elective subjects? The natural result of this procedure is that the students follow the line of least resistance, taking the easy subjects. Professor Ernst Cohen, the noted Dutch Chemist of Utrecht, Holland, in an address at the meeting of the American Chemical Society in Philadelphia said, "Your university students are babied too much: they have too little initiative: everything is told them in lectures." Is it not true that our high-school students are also being "babied" too much? This would seem to be true when only ten per cent of our high schools are requiring chemistry.

*Second*, the number of students interested in the subject of chemistry is altogether too small. Something is wrong when ninety per cent of our high-school students are graduating without taking a course in chemistry. In the words of William J. Hale, "We live in a chemical world and our daily life is just a little group of chemical reactions under proper coördination."

If it is true that the subject of chemistry is of immense value in the appreciation and interpretation of our everyday environment and is necessary for the understanding of so many of the processes which affect our daily life then, certainly, every boy and girl ought to know something about chemistry, one of the most vital of all subjects.

*Third*, when we study the data obtained on the matter of teaching load, extra-curricular activities, and the range of subjects assigned to the teacher of chemistry it seems that the chemistry teachers are imposed upon in the amount of work they are required to do. Herein are some of the factors affecting the efficiency of the teaching of chemistry and in a measure responsible for the criticism laid at the teacher's door. Chemistry teaching in our high schools will be more effectively done when the teaching load is not more than five hours per day, including laboratory periods. No high-school teacher can be expected to do good work when asked to teach five or six different subjects.

## Training and Experience

Let us next inquire into the training of the chemistry teachers. We find that sixty-two are graduates of a college or university while ten have completed their training in a normal school or state teachers' college. Of the seventy-two teachers reporting there are only seven, or slightly less than ten per cent, without a degree. Of the sixty-two graduates of a college or university, ten were also graduates of normal school, having taken additional work since graduating from the normal school. The range of the degrees held by the chemistry teachers of the high schools of the state make an interesting study. In the order of frequency they are: B.A. 26; B.S. 24; Ph.B. 10; M.S. 5; M.A. 5; B.Ed. 1.[2]

**Time Given to the Study of Chemistry.**—Another angle in the matter of training is indicated by a study of the facts obtained in answer to the question, "How much time have you given to the study of chemistry?" These facts are tabulated below:

TABLE II

| Number of years | Number of teachers | Per cent |
|---|---|---|
| One | 7 | 9.8 |
| Two | 19 | 26.3 |
| Three | 10 | 13.8 |
| Four | 20 | 27.7 |
| Five | 13 | 18.0 |
| Six | 3 | 4.1 |

From these figures we find 49.8 per cent have given four years or more to the study of chemistry. When we analyze the returns on the matter of

[2] The total number is more than sixty-two for the reason that in cases where more than one degree is held all are included in the list.

whether chemistry was taken as a major while in college the situation may be summed up in this way: only fifty-seven per cent of the chemistry teachers took chemistry as their major while in college.

**Experience in Teaching.**—Another very important factor in the training of a successful chemistry teacher is the number of years of experience.

TABLE III

| Years of Experience | Number of teachers | Per cent |
|---|---|---|
| Two or less | 34 | 47.2 |
| Five or less | 59 | 82.0 |
| More than five | 14 | 18.0 |

The striking fact is that of the seventy-two teachers there are only fourteen who have more than five years' experience in teaching chemistry. Although there is one teacher in the state who has taught chemistry for more than thirty years the average length of service is slightly more than two years.

**Conclusions.**—*First*, the chemistry teachers of the state present a very creditable showing in the matter of degrees held and the number of years devoted to the study of the subject. More than ninety per cent have degrees and practically fifty per cent have given at least four years to the study of chemistry. While these facts present a very commendable showing there is still room for improvement. The minimum requirement for all teachers of high-school chemistry should be four years of study beyond the high school with a bachelor's degree from a college or university.

*Second*, for all those who expect to teach chemistry in high school, chemistry should be pursued as a major while in the university or college. The facts obtained on this point indicate that forty-three per cent of those now teaching chemistry majored in some other subject. This situation may be partially explained by the fact that when they were employed to teach they could not find positions in their special field so they accepted positions without regard to special preparation. It is needless to say that a practice of this kind is not conducive to good teaching. In our teacher training schools there is a need for developing the idea of training in the particular subject which the student expects to teach, and when placing teachers to place them on the basis of training and not simply find them jobs.

*Third*, in the number of years of experience we find eighty-two per cent are teaching chemistry for five years or less. If it is true that a teacher reaches his best after an experience of ten or more years, then certainly we need more of the professional atmosphere among teachers of chemistry and less of the altogether too common practice of teaching chemistry as a stepping stone toward something else. The universities and colleges can do much to discourage this practice and to create a professional spirit

in which the length of service will be very much increased over that existing at present.

## Methods

The writer has had the feeling for some time that an adequately trained chemistry teacher should have a knowledge of the science of teaching as well as the science of chemistry. This feeling was further strengthened by the response to several questions included in the questionnaire. The first question asked in this connection was, "Have you had a course in the teaching of chemistry?" to which 37.5 per cent answered in the affirmative and 62.5 per cent gave a negative answer. While nearly one-third of the chemistry teachers of the state had not taken courses in the teaching of chemistry they indicated the high regard they had for such a course by the following answers to the question, "What change would you suggest which would have given you a more thorough preparation for the teaching of chemistry?"

"A good course in the teaching of chemistry." "Directed practice teaching." "More teaching from the viewpoint of high-school students instead of research." "A course in teaching methods for science." "A teacher course in practical chemistry." "A good course in the teaching of chemistry, practical and not theoretical, taught by a man who knows how to teach." "Possibly a little more pedagogy, however, pedagogy without subject matter is not much good." "Teach a class while in school." "More practice teaching in chemistry." "More attention to methods and less to subject matter." "Better teaching on part of college teachers." "A course in the management of the laboratory." "Courses under more pedagogical teachers." "More chemistry courses, practical teaching under supervision." "A course in demonstrating chemical laws and theories."

**Study Habits.**—The development of study habits presents another aspect in connection with methods of teaching. In answer to the question, "Do you find that your students do not know how to study?" sixty-three gave *yes* and one wrote *no*. Then this question followed: "Do you favor any improvement in the methods of study in chemistry?" Thirty-three gave *yes* for an answer and some of the suggestions offered follow.

"More independent work on the part of the pupil and less following set instructions." "More of the good old-fashioned study." "Omit some of the technical material." "Put more time on fundamentals." "Most students are not vitally enough interested in wanting to study to put the necessary time on technic of study." "Project work as far as possible with equipment, conditions, etc." "Laboratory study periods would be an advantage." "A more practical preparation in arithmetic." "I think it might be well to have supervised study periods in chemistry." "There

should be supervised individual study and laboratory work the entire first semester. A second semester should allow project work (student initiative)." "I favor methods of inducing pupils to use some systematic method of study." "I favor using half of the recitation period for study." "I think more objective work than is found in most texts would be of value."

One of the chemistry teachers of the state writes that he is using the project method in his chemistry class. The pupil proceeds as follows: (1) Receives mimeographed sheets on which are typed certain experiments designed to arouse his curiosity about the general subject of the project, so that he is not satisfied until he reads extensively on this and related topics. (2) Does experiments, taking notes and writing down generalizations. (3) Comes to instructor for conference, where mistakes in conclusions are pointed out and best references are suggested. There is no adopted text. Each fall all pupils contribute to a fund with which we purchase twenty-five or thirty copies of the leading texts on the market. From this large variety the pupils read until satisfied in regard to the project on hand. (4) Comes to instructor for a mimeographed test. The mark depends both upon the quality and the quantity of work done. All students work independently, as fast or as slow as intelligence or ambition dictates. This system has its weak points, of course, but certainly holds the interest and enthusiasm of the extremely bright and the woefully dull to a remarkable degree.

One teacher writes as follows: "There has been something wrong in my chemistry courses but it is difficult to locate the trouble. High-school juniors as a rule do not do much outside work. Then, too, chemistry ought to be made as practical as possible in the high school and the choosing of subject matter is a problem. But in making chemistry practical there is a danger of making it too general and not developing the underlying principles of the subject. I have found most success in making a thorough study of subject matter and developing a laboratory technic during four of the six periods, letting the students work up special projects during the last two periods. Then have them report to class on their work."

Another writes: "Teachers should be well prepared in college or normal schools in special subjects. But specializing too greatly is not advisable because most of your students must start teaching in a small high school. That means that they are required to teach three or four sciences. Few normal school or university graduates can obtain a one-subject job without three or four years of experience. But if a teacher has had good training in how to think and act scientifically and has had practical training in the classroom under excellent supervision he is able to do his work well."

**Subject Matter Difficult to Teach.**—In answer to the question "What

phase of chemistry do you find the most difficult to teach?" the following replies were received: mathematical side, 18; balancing equations, 16; valence, 14; theoretical parts, 9; gas laws, 7; theory and law, 5; periodic law, 4; formulas, 4; theory of ionization, 3; abstract principles, 2; application of problems to the work, 2; colloids, 1; radioactive elements, 1; weight and volume relations, 1; atomic structure and classification of elements, 1; qualitative analysis, 1; correlation of class work with laboratory, 1. Some other striking answers are as follows: "Problems are too difficult for the time they are worth." "Practically all my trouble has been caused by equations." "Laws and theories, especially to the weaker one-third of pupils." "Mathematical presentations, particularly the determination of molecular weights."

**Other Problems of the Teacher.**—Representative replies to the question: "What problems, not already mentioned, have you been confronted with in the teaching of chemistry?" follow.

Many of the students lack the fundamentals; especially in working problems is this noticeable. Mathematics poor in many cases.

It is difficult to show students the practical value of a general course. If this could be done more real interest could be aroused.

Trying to impress upon them the need to do individual work in the laboratory and to respect the property of others.

I think the greatest difficulty comes from lack of knowledge of the subject and teaching *about* chemistry rather than teaching chemistry.

Tendency of students to memorize instead of reasoning in application of laws, formulas, etc.

The problem of a balance between enough popular and extraneous material to keep the students interested and enough solid chemical facts to give them a basis for further work.

The textbooks do not go into detail enough on practical uses and applications of elements and compounds.

I believe the greatest difficulty lies in the fact that the students do not know how to study.

The students seem to take laboratory and recitation work as two separate studies. It is hard to get them to see the relation.

Stimulating interest in the first part of the course as presented by most textbooks.

Many students even at end of course are not able to pick out important facts in text and in studying they place equal emphasis on all statements.

Mainly the problem of the student who has had a poor preparation for his science work.

A suitable method for the writing up of experiments which will require a reasonable length of time to check over and correct.

Meeting needs of pupils who go to college and the needs of those who will not go.

The problem of making chemistry a vital subject that will function instead of a mere textbook subject.

The problem of measuring achievement in a scientific manner. The problem development of the scientific attitude, without enforcing pupils to make a catalog of facts and formulas out of his brain.

Problem of carelessness in the laboratory and an attitude of hurry and get through with the experiment.

Securing good high-school textbooks.

Laboratory instruction too scant in high schools.

Difficulty of pupils to comprehend fundamentals, generalize, see relationships, comparisons, etc.

I have found it necessary but difficult to secure enough practical experiments touching intimately the pupils' daily life.

I find it very difficult for students to know what they are doing in the laboratory. Too many just follow instructions.

I feel that chemistry requires more time than ordinarily is given to it. It requires carefully supervised study periods.

**Conclusions.**—The writer has the presumption to draw a few conclusions upon the importance and place of methods in the training of adequately prepared chemistry teachers based upon the facts obtained from the questionnaires. These facts seem to bear out the contention of Dr. Downing when he makes the statement: "strange as it may seem, the teachers of scientific subjects have been the last to adopt scientific methods of presenting the subject matter." The teachers of chemistry along with the teachers of other science subjects have been slow to appreciate the importance of the methods side of presentation. However, the answers to the questionnaires show that the chemistry teachers in the field feel a very definite need for methods and practice teaching as a part of the training of every chemistry teacher.

There is a belief among some college graduates that the possession of a degree in chemistry is the only qualification necessary for the teaching of the subject. While it is true that knowledge of the subject is indispensable, that is not the only qualification of a good teacher. The possession of a master's or doctor's degree is no more a guarantee of teaching ability than the mastery of all the football rules is a guarantee of excellent playing ability. It is not my purpose to minimize the importance and value of a degree but it does seem entirely possible that a graduate in chemistry could easily be a master of the subject and not be able to impart his knowledge to others. The trouble is, it seems to the writer, that the graduates of our universities are trained to be specialists in their major subjects but for the most part are not familiar with the best methods of presenting those subjects. On the other hand, among some educators there is the belief that a graduate of a teachers' college and supposedly a master of the method and technic of teaching is equipped to teach any subject in the curriculum. This false notion is more disastrous than the former for the reason that perfection in method cannot be expected to compensate for a lack of knowledge of subject matter.

If the universities and teachers' colleges are to meet the demand for adequately prepared teachers in the field of chemistry they must provide the training in which will be found the proper balance between subject

matter and method; then when their training is complete to use every effort to see that the graduates are placed in positions they are best prepared to fill. A very important part of this program is to put the right man in the right place, for as someone has said, "to put the right man in the right place should be one of the chief aims of education." Then, and only then, will the boys and girls of our high schools receive courses in chemistry under the leadership of highly trained chemistry teachers.

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**Synthetic Cane Sugar Declared Unlikely.** The proposition of commercial synthetic cane sugar is pure "moonshine," in the opinion of Sir James C. Irvine, Britain's greatest sugar chemist, speaking at the recent Institute of Chemistry of the American Chemical Society at Evanston, Ill. Even admitting that the two mother substances of common sugar, glucose and fructose, were to be obtained from nature, the last step in uniting the two presents enormous difficulties. Apparently, there is little hope of a process much more economical than that of Prof. Amé Pictet, whose discovery of synthetic sugar received wide publicity recently.

In a survey of the very difficult laboratory researches leading to synthetic sugar, Sir James pointed out the chameleon-like habits of both glucose and fructose. Each of these, instead of being a single kind of sugar, is really a small host in itself. Actually several different species of sugar ride under the one common name. While these are naturally much alike, it is only one particular kind of glucose combined with one specific fructose which will yield genuine cane sugar. To add to the problem, the different varieties change into one another, unobserved, during manipulation.

A change from one variety of glucose or fructose to another is usually the transfer of oxygen atoms from one carbon atom to another within the sugar group. No material is lost or gained, so that the ordinary analytical chemist, using balances and common laboratory apparatus, would not suspect that anything had happened.

Neither Pictet nor Irvine have yet demonstrated clearly just what kind of each sugar goes into the cane sugar combine, so that it is still impossible to write the formula of the final product with certainty.

Although the glucose component is commercially available at low cost from corn, the fructose is more expensive than natural cane sugar itself. In view of the fact that the production of a teaspoonful of synthetic cane sugar would probably take the time of a highly paid chemist for several months, to say nothing of supplies and overhead, it is thought that the practical production of sweetness will be left to the lowly beet and cane for a long time.—*Science Service*

**Determine Standard for Beri-Beri-Preventing Rice.** A simple test for determining rices that will prevent beri-beri in human beings and polyneuritis in pigeons and other fowl has been developed by Dr. Edward B. Vedder of the U. S. Army Medical Corps stationed at Manila and R. T. Feliciano, chemist of the Manila Bureau of Science.

The rice grains are stained with an iodine solution, the starch granules taking on a blue color. The proportion of external layers, which remain unstained, and which contain the beri-beri-preventing factor, may be determined with reasonable accuracy by simple inspection, report these investigators.

This method is so quick that it may be used during the milling process to determine the degree of milling. A chemical index for beri-beri-preventing rice was also determined.—*Science Service*

# A GENERAL DEFINITION OF ACIDS, BASES, AND SALTS*

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Recently there has been a renewed interest in the study of the physical properties of and the reaction between electrolytes in non-aqueous solvents. Such studies sometimes lead to explanations of many of the reactions as being between acids and bases of the various systems but, as yet, a completely consistent nomenclature has not come into general use. For this reason it was thought worthwhile to offer definitions for a group of terms which would be applicable to all solvent systems.

In water solutions the characteristic properties of acids are considered to be due to the hydrogen ion and those of bases to the hydroxyl ion. Franklin[1] has shown that in liquid ammonia solutions, the ammonium ion, which may be looked upon as an ammoniated hydrogen ion, has properties similar to those of the hydrogen ion in water, and ammonium salts behave as acids when dissolved in anhydrous liquid ammonia. Now water itself is ionized to a slight extent and its positive ion is identical with that of the acids of the water system. In the same way, ammonia ionizes, furnishing the same cation as that of the ammonium salts, which are acids in ammonia solution.

The authors presented at the Birmingham Meeting of the Society a general conception of *an acid*[2] for any system involving an ionizing solvent as being a substance, which forms by its direct ionization, only cations identical with the positive ions formed by the ionization of the solvent molecules. The kind of cation which is common to the solvent and all substances which behave as acids when in solution in that solvent will be called the *acid ion* of the system, and properties common to all acids in that solvent will be the properties of the acid ion. Germann[3] has shown that in general the acid ion will, through a process of *solvation*, be united with one or more molecules of solvent to form a complex ion.

The objection might be raised that, since hydrogen acids may in general be obtained in the anhydrous state, the typical acid ion, the hydrogen ion, is non-solvated, but a great many acids may be obtained with water of crystallization, which water may well be, at least in part, water of solvation of the actual or potential hydrogen ion. Then, too, in general, heating ammonium salts causes the well-known dissociation into ammonia and the anhydrous acid exactly analogous to the decomposition of a hy-

* Read before the Division of Chemical Education of the American Chemical Society at the St. Louis Meeting, April 18, 1928.

[1] *Am. Chem. J.*, **41**, 285 (1912).

[2] *Science*, **56**, 27 (1922).

[3] *Ibid.*, **61**, 71 (1925).

drate into water and the anhydrous acid. So the difference is merely a matter of degree of stability when out of solution.

A distinction should be made between a substance which behaves as an acid when dissolved in a given solvent and an acid of that solvent system. *An acid of a system* may be looked upon as a substance derivable, at least theoretically, by the union of one or more anions of the solvent with one or more atoms of a non-metallic or acid-forming element with or without the subsequent loss of molecules of solvent. For example, the familiar nitric acid may be considered as being formed by the union of five hydroxyl and one nitrogen atom, forming $N(OH)_5$ with the subsequent loss of two molecules of water, giving $HNO_3$. On the other hand, while hydrochloric acid is a typical acid it does not belong to the water system because it cannot be formed from chlorine and the hydroxyl ion by any process of dehydration. Hypochlorous acid and the other oxy-acids of chlorine are additional examples of acids belonging to the water system. In the same way, while ammonium nitrate exhibits all the properties of an acid in liquid ammonia solution it is not an ammono acid while hydrazoic acid, $HN_3$, is ammono nitric acid. This fact was pointed out by Franklin.[4]

In a similar way we may define *a base* as a substance whose molecules yield by a process of direct ionization only anions identical with those formed by ionization of the solvent molecules. The kind of anion common to the solvent and all bases of the system is the *base ion* which may or may not be solvated.

A solution is *acidic*, *neutral*, or *basic* accordingly as the concentration of the acid ion in that solution is greater than, equal to, or less than its concentration in the pure solvent. It follows at once from our definition of acids and bases that in general the acid ions of an acidic solution which is mixed with a basic solution will react with the basic ions to form undissociated solvent molecules. This reaction is called *neutralization* and when stoichiometric quantities of an acid and a base have reacted together a solution of *a salt* remains.

*A salt* may be defined otherwise than by the method of its formation as a substance whose solution in a solvent has an electrical conductivity of a higher order than that of the pure solvent, and which by a process of direct ionization yields at least one kind of cation and one kind of anion different from those formed by direct ionization of the solvent. A salt may also yield a cation common to the solvent in which case it is an *acid salt*, or an anion common to the solvent when it is a *basic salt*. Salts which are incapable of ionizing directly to yield any kind of ion common to the solvent are called *neutral salts*, though their solution may be either acidic, basic, or neutral. The reaction between a salt and the solvent to yield other than a neutral solution is called hydrolysis for water solutions.

[4] *J. Am. Chem. Soc.*, **46**, 2141 (1924).

ammonolysis for liquid ammonia solutions, and may in general be called *solvolysis*.

One might apply these general definitions to a system where the solvent contains no hydrogen such as solutions in liquefied anhydrous sulfur dioxide. Sulfur dioxide like most ionizing solvents is itself, when pure, a very poor conductor of electricity and is presumably only very slightly ionized. A probable[5] mechanism for its ionization is as follows:

$$2SO_2 \rightleftharpoons SO^{++} + SO_3^{--} \qquad (1)$$

From our general definition of an acid any substance which dissolves in sulfur dioxide to give $SO^{++}$ as its cation will be an acid provided, of course, that equation (1) really represents the true mechanism of the sulfur dioxide ionization. Such a substance as thionyl chloride, $SOCl_2$, might possibly dissociate as follows:

$$SOCl_2 \rightleftharpoons SO^{++} + 2Cl^- \qquad (2)$$

and if it does we have our acid. If the sulfites ionize in sulfur dioxide in the same manner as they do in water solution cesium sulfite will dissociate to give the sulfite ion which, still taking for granted that equation (1) is correct, is an anion common to the solvent and, therefore, is the base ion of the sulfur dioxide system. Thus, cesium sulfite, a base, should react with our acid thionyl chloride to form sulfur dioxide and leave a solution of a salt, cesium chloride, and the equation for our expected reaction might be written as below:

$$SO^{++} + 2Cl^- + 2Cs^+ + SO_3^{--} \rightleftharpoons 2Cs^+ + 2Cl^- + 2SO_2 \qquad (3)$$

That the above reaction does take place has been shown by Puffett[5] and, if we wish, we may describe this reaction as one of neutralization whereby an acid, thionyl chloride, has neutralized a base of the sulfur dioxide system, cesium sulfite, the sole reaction being the union of the acid ion, $SO^{++}$, with the base ion, $SO_3^{--}$, to form undissociated solvent molecules. Our base, $CsSO_3$, may be properly spoken of as a base of the sulfur dioxide system for it may be considered as being derivable from sulfur dioxide by replacement of the $SO^{++}$ ion formed according to equation (1) by the strongly metallic element cesium. On the other hand, the acid, thionyl chloride, is not an acid of the sulfur dioxide system because it cannot by any type of juggling be considered as derivable from sulfur dioxide by the replacement of the $SO^{++}$ ion by the acid-forming element chlorine. Therefore, thionyl chloride, though ionizing as an acid when in sulfur dioxide solution, is not a compound of the sulfur dioxide system.

One might attempt to extend this general conception of acids, bases, and salts to mixtures of fused salts but the value of such an extension

[5] Dale H. Puffett, "A General Conception of Acids and Bases." Master's thesis, University of Kansas, 1923. Unpublished.

would be very doubtful, for a fused salt, even when carefully purified, is highly ionized; and, while we could classify the salts fused or dissolved in such a molten solvent as acids or bases, as the case might be, still because of the high auto-ionization of the solvent, our acids would refuse to neutralize the bases and the classification would be meaningless in most cases.

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## A CONVENIENT FORM OF HYDROGEN SULFIDE GENERATOR

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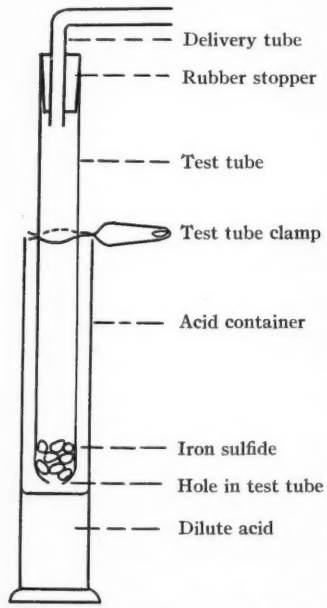
An eight- or ten-inch ignition tube will serve best for a generator. Grind a small hole about one-sixteenth of an inch in diameter in the end of the tube. A small piece of glass will answer the purpose for a surface upon which to grind the tube. Introduce a few large pieces of ferrous sulfide into the generator and attach a suitable delivery tube to it.




POSITION OF GENERATOR WHEN NOT IN USE

In order to set the generator in operation place the tube with its iron sulfide into a rather tall narrow container which has some dilute hydrochloric acid in it. A graduate just a little larger than the generator is very satisfactory. If the delivery tube is under the surface of the solution into which it is conveying the gas there will be a little back pressure in the generator. This will cause the level of the acid in the outside container to rise so that there may be danger of its running over the top. After a few trials one can easily estimate the proper amount of acid to use. When the generator is not in use it can be raised up out of the acid and clamped in place with a test-tube holder. This allows the acid to drain out and the reaction stops.

The writer has found this type of generator very economical in acid consumption. The student also seems to accept it very readily for his laboratory work, especially in the experiments in qualitative analysis. Three such tubes for hydrogen, carbon dioxide, and hydrogen sulfide, respectively, kept in the teacher's private laboratory, will be found to conserve his time.

# AN EXPERIMENT IN QUANTITATIVE ANALYSIS FOR GROUP PERFORMANCE

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An excellent opportunity for teaching certain principles is afforded by having each student in a class in quantitative analysis make one of a series of determinations on material which is undergoing a gradual change of composition. Such procedure has also several practical advantages from the standpoint of the teacher. Perhaps the simplest type of reaction that may be used in this way is that of the hydration and the dehydration of salts. A considerable amount of literature has been devoted to the rate of such reactions under different conditions but, as far as the author has been able to find out, no reference has been made to the application of these reactions in teaching. The study of a salt, which is losing or gaining water, may readily be made by the determination of one constituent of it from time to time. Copper affords, perhaps, the most practical salts for this purpose. They are readily hydrated and dehydrated under conditions which may be regulated, and the electrolytic determination of copper is one of the most accurate determinations made by a class in elementary quantitative analysis. Reasonably satisfactory results may be obtained by the average student without the running of a duplicate determination.

In the author's laboratory the following plan has been used for the past four or five years with good results. First of all, part of a class period is devoted to a discussion of the vapor pressure of hydrated salts and a review of the principle of a desiccator. The plan used for the experiment by the whole class is explained, with the remark that some of the determinations will be made on the material undergoing change, while others will be made on the original as a check. A schedule of dates is then posted in the laboratory upon which each student reserves a day convenient to him to make the determination. One or two analyses may be made on a single day, but it is well to have the whole experiment cover a number of days. The size of the class will determine how many should work each day or each week. After one or more preliminary analyses on the original salt, some of it is placed in a desiccator jar over the proper reagent, and samples taken therefrom, by the instructor, at the time that they are to be used. Before each removal the material is well mixed by stirring to insure uniformity and to expose a fresh surface to the atmosphere. After the student has performed the analysis by the usual electrolytic method, he reports, along with all weighings, the percentage of copper in the sample, and also the average molecular weight of the salt, assuming there to be only one atom of copper in the molecule. This may be extended by telling the student the nature of the salt that he has (sulfate, nitrate, etc.) and requiring him to calculate the number of molecules of water in the material, or the percentage of the de-

hydrated and hydrated salts, or the two hydrated salts as the case may be. These calculations are of more lasting value to the student than mere "theoretical problem" work, because they are based upon actual data obtained by him, and few if any other experiments afford just these types of calculations. The students' ability to calculate similar but more difficult problems after having performed this experiment is gratifying.

After the results have been reported by the whole class, the instructor arranges them and plots the reported molecular weights against the time (in days) on which each was determined. From the general form of the curve obtained it is a simple matter to assign grades to each student for the work performed. Sometimes, of course, a break in the curve shows the change of system of the hydrated salts, and this must be taken into account. No grades are assigned until all results have been reported. The graph is then exhibited to the class, and some of the principles are again discussed, this time in the light of the experimental data obtained by the class. This always arouses interest on the part of the students. Later on, when the same students are studying about heterogeneous equilibrium in the course in physical chemistry, they will already have had some direct contact with the subject, and this experiment can be used to advantage as an example.

Some actual cases may be cited, in which copper sulfate was used. Hydrated copper sulfate ($CuSO_4 \cdot 5H_2O$), freshly ground, was placed in a desiccator over anhydrous calcium chloride. This lost water at a constant rate until a compound remained at the end of approximately ten days with the formula close to that of the trihydrate. Little further dehydration was noted at the end of an additional twenty-five days. In Table I are shown the most significant results that were obtained for this series by one class.

TABLE I

DEHYDRATION OF $CuSO_4.5H_2O$ BY $CaCl_2$

| Time (days) | Mol. wt. reported |
|---|---|
| 0 | 254.0 |
| 2 | 245.7 |
| 4 | 241.5 |
| 6 | (224.8) |
| 10 | 216.5 |
| 16 | 214.8 |
| 35 | 214.2 |

Check analyses on original material and additional ones on the final product are omitted from the table. The first determination listed was run on the original material. Similar results were obtained when concentrated sulfuric acid was substituted for the calcium chloride. A rather interesting experiment was run by placing samples of dehydrated and of hydrated copper sulfate in the same container. A sample of this salt with a molecular weight of 174 (chiefly $CuSO_4 \cdot H_2O$) gained ten units in its molecular

weight when placed over the pentahydrate for twenty-five days. Table II shows the result obtained by exposing to the air some partly dehydrated copper sulfate.

TABLE II

HYDRATION OF COPPER SULFATE IN AIR

| Time (days) | Mol. wt. reported |
|---|---|
| 0 | 166 |
| 3 | 175.8 |
| 6 | 183.1 |
| 8 | 192.9 |
| 13 | 231.0 |
| 14 | 237.5 |
| 17 | 249.3 |
| 20 | 250.3 |
| 21 | 249.8 |
| 38 | 249.3 |

Here, of course, the humidity of the air will change from day to day and a uniform rate of hydration cannot be expected. In all of this work the salt was recrystallized from distilled water. The dehydrated salts were easily obtained by the careful heating of the pulverized material in a combustion tube over a direct flame. A current of air, dried by bubbling through concentrated sulfuric acid, carries off the water evolved. A little experience will show how hot the material may be heated without any loss of sulfate.

Many other reactions might be tried in a similar way. Dehydrations with phosphorus pentoxide, calcium oxide, etc., should yield good results. With calcium carbide the reaction is said to continue until the monohydrate ($CuSO_4 \cdot H_2O$) has been formed. Hydration by various hydrous salts could be tried out, and also the formation of ammoniacal salts by means of the proper reagents. For the best results the reactions must be reasonably slow, yet fast enough to give distinct variations in compositions within the time allotted to the experiment. The general method might conceivably be applied to some constituent other than copper.

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**Corn Borer Likes Tall Corn Best.** The European corn borer likes tall corn best, according to G. A. Ficht of Purdue University. That the height and age of the corn has something to do with its attractiveness has been made evident by his experiments. A corn plant that is about two feet high seems to be an alluring place for the corn-borer moth to lay its eggs, while the plant that is only a few inches high is rarely attractive to these pests.

Mr. Ficht explains this peculiar behavior on the theory that the larger plants have an odor all their own. The moth, influenced by this odor, prefers to lay its eggs there. This is the reason we find corn-borer worms feeding, not on the tender shoot just above ground, but on the hardy advanced plant.—*Science Service*

# DOES LABORATORY WORK BELONG?*

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Are we giving too much laboratory work in chemistry? During the past decade, this question has been threatening to disturb our complacency. From time to time, studies of the efficiency of demonstration as contrasted with individual laboratory work have been reported. If we accept the recommendations accompanying these reports, we should curtail the laboratory work and give instruction largely by teacher demonstration. On the other hand, practice in secondary schools remains about as before; while the College Entrance Board and the American Chemical Society, as well as other authorities, continue to recommend and to require laboratory work. The purpose of this article is not to advance arguments for either view, but to present some facts recently collected which may assist in a rational answer, or may even alter the question itself.

Faced with the necessity of deciding the policy of one school as to the amount and nature of the laboratory work, and confused by the diversity of opinion and practice, the writer undertook to collect some facts. The study extended over a period of three years and aimed; *first*, to evaluate traditional practices, and *second*, to test the outcomes of some authoritatively recommended modifications of these practices. The data were collected, for the most part, in the Seward Park High School, New York City, where a carefully planned program of controlled experimental teaching was carried out during the years 1925–27.

## General Conditions

These facts have most significance when viewed against the background of the situation in this school. While every school differs, of course, in some particulars from every other, there are certain practices which may be called typical. I believe our practices are typical; but a brief description will enable the reader to judge for himself. We have from 700–900 pupils enrolled in chemistry each term. The subject is elective—usually in the second year of high school. Promotions are made half yearly and the 12 sections of Chemistry I become 10 sections (more or less) of Chemistry II. These sections are not promoted as units but are entirely broken down at the end of each term to be rebuilt by a program committee of the school. The chances, then, of a student having the same teacher for the whole year's course, are about one in six; for six teachers devote all their time to teaching this subject. Instruction is given to each class one period of 50

*This study is a summary of some of the findings reported in a dissertation offered in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Teachers College, Columbia University, in the Department of Natural Science. A complete report of the study is available as a monograph from the Bureau of Publications of Teachers' College, New York City.

minutes each day for five days per week. Of these weekly periods; one consists of individual laboratory work in adequately equipped laboratories, one is a teacher demonstration, and three are recitation or discussion periods. Homework, consisting of readings in a textbook and of written answers to questions, is assigned three times per week; and in addition, a record of all experiments, both individual and demonstration, is formally written in notebooks. Directions for performing the laboratory exercises in the form of mimeographed booklets are in the students' hands, serving as a guide for the operations to be made and for the subsequent notebook record. The syllabus of topics as outlined by the Board of Regents of New York State is used as a guide. Weekly quizzes, a mid-term test, and a final test are given each term. The State Regents' Examination in chemistry constitutes the final criterion of success at the end of the second term. Teachers' personalities find expression, to be sure, in the classroom, but by means of a very carefully detailed term and weekly plan, as well as by frequent conferences and by supervision of the chairman, the instruction is as uniform as it ought to be.

The experimental methods used in our study are known commonly as the *equivalent-groups method* and the *rotation method*. Two different bases were used for equating, and in such a way as to serve as a check on each other. The *rotation method* likewise served to check the equivalent-groups method. Most frequently, in educational experimentation, where equivalence of groups is desired, some form of intelligence test seems to be selected as the basis. This is, of course, only justified when it has been established that the trait in question correlates highly with the intelligence test used. In so far as the equivalent-groups method is valid for a scientific investigation, it appears to assume that two groups can be so selected that if they were subjected to the same treatment, the resulting changes would be the same. This means initial equivalence in the trait in question and in capacity to modify this trait.

A preliminary study of the correlations between chemistry ability as measured by Powers Chemistry Test, Regents' chemistry marks, and our own school tests showed very little relationship with intelligence test scores in the Terman Test or in the National Intelligence Test. Without trying to explain this, we discarded the general intelligence test as a basis of equating. We found that biology Regents' marks correlated more closely ($r = 0.54 \pm 0.04$) with chemistry marks than any other of the measures used. We, therefore, used the biology marks as the basis for the equating in the first series of experiments. The next term we equated on the basis of the scores in the mid-term examinations in chemistry, which is a measure of the traits we are attempting to modify. We found that the correlation between the mid-term and the final examination in chemistry was measured by $r = 0.94 \pm 0.02$.

As already stated the sections in chemistry are made by a program committee of the school and students are distributed quite at random in different sections. We found the groups fairly equivalent, therefore, but made them statistically so by considering the groups equivalent when their means and the standard deviations were equivalent. In all of these groups, moreover, every precaution was taken to eliminate or to equalize such factors as teacher, time of day, lesson assignments, rate of progress, etc. As the classes were all in one school under the personal supervision of the writer, it was possible to maintain this control consistently and thoroughly. Also, since we approached the problem in the spirit of pure inquiry, for the avowed purpose of getting guidance for our practice rather than with a desire to promote or defend any intrenched practice, the element of bias was practically absent.

## Experimental Study with Results

The experimentation was carried on so as to make several comparisons simultaneously, but we can consider the results in two divisions: (*a*) in terms of written tests, (*b*) in terms of non-written tests.

*Written Tests.*—In making the written tests, the course was sampled carefully with a view to giving weight in the test proportionate to the emphasis or time allotted to the topics. All questions were designed so as to be objectively scored. All questions and the examinations as a whole were judged by seven teachers to be fair and adequate measures of what could be reasonably expected of the pupils; and the committee system of marking, using a key, assured uniformity in scoring.

The first comparisons were between results of individual laboratory work and demonstration work (using printed directions for both). The work was made uniform on four days per week. On the laboratory day, one group received instruction individually by doing an experiment in the laboratory, using directions printed in a manual. The other group received instruction on the same experiment by watching the teacher demonstrate it. Both teacher and class followed the same directions from the same manual. Discussion and exposition were avoided in both groups. The mid-term and final examinations give results which may be called the normal outcomes of the method measured in the customary way and including the factor of retention. The results of the written tests with the rotated groups, when interpreted by the rotation method alone, give a picture of the immediate effects of the two methods in learning the two topics, ammonia and nitric oxide; but since the groups had been previously instructed by the contrasted methods, and equated, the effects of this period of training could also be measured in terms of the ability to learn these topics. Table I shows the differences in ability to score on written tests, the direction of the differences and the

probability of the difference being truly greater than zero, between the methods of the demonstration and individual laboratory work following printed directions.

TABLE I

RESULTS OF THE WRITTEN TESTS

| Test | Year | No. pupils Indiv. | No. pupils Dem. | Means Indiv. | Means Dem. | Difference | No. items | Difference / sigma (diff.) |
|---|---|---|---|---|---|---|---|---|
| Mid-term | 1926 | 379 | 85 | 77.75 | 72.60 | 5.15 | 119 | 2.51 |
| Final | 1926 | 351 | 85 | 43.60 | 40.95 | 2.65 | 63 | 2.09 |
| Rotation (immediate effects) | 1926 | 43 | 43 | 15.39 | 15.28 | 0.11 | 45 | 0.05 |
| Rotation (training effects) | 1926 | 43 | 43 | 17.51 | 13.16 | 4.35 | 45 | 2.52 |
| Final | 1927 | 128 | 63 | 41.08 | 39.30 | 1.78 | 57 | 1.63 |
| Regents' | 1927 | 51 | 46 | 83.65 | 83.30 | 0.35 | ... | 0.19 |

Some of the facts from the table which should be especially noted are:

1. The differences between the mean scores are in favor of the individual method in all cases.

2. The differences are small when compared to the size of the means themselves.

3. The reliability of these differences (using 3 times sigma of the difference is acceptable) in no case meets the requirements of practical certainty.

4. The difference in the results of the two methods is so slight in the case of the effect of training on one topic measured immediately that the chances of the true difference being greater than zero are practically even. This is indicated by the rotation data (immediate effects) where the difference is 0.5 times sigma which is statistically equivalent to 50 chances in 100.

5. The differences in terms of the regular department tests and the reliabilities of these differences corroborate each other and make a consistent picture.

6. The difference as measured by the Regents' examination is least and least reliable, next to the previously mentioned difference in immediate effects of a single exercise.

Some of the inferences which it seems safe to draw from these data are:

1. The methods of demonstration or individual laboratory work, following directions, make only slight difference in the ability of students to succeed in written tests of the informational type. This may mean that either method presents about the same amount of information; or that the fund of information and the ability to use it in answering questions is largely acquired from the other factors in the instruction—the teacher, home reading, and class discussion or drill.

2. Written tests are not suitable instruments for measuring differences

which may exist between the effects of individual laboratory work and teacher demonstration.

3. If the written test is to be the sole criterion for success in chemistry it makes little difference whether we use demonstration or individual work in connection with the recitation and textbook.[2] For purposes of passing Regents' examinations this appears to be particularly true; but it is also true that on account of the non-objective character of the Regents' examination, its own reliability is low.

4. The slight though consistent difference in favor of the individual laboratory method in terms of the written tests, which involved the effects of several weeks of training, suggest that there are possibly some outcomes of the individual method which the written test just barely detects but cannot reliably measure.

5. Differences in the outcomes of the two methods must be looked for elsewhere and by other methods than written tests—possibly in the pupils' attitudes and possibly by manipulative tests if any can be devised.

*Individual Performance Test.*—With this preliminary evaluation of our methods, we addressed ourselves to the problem of detecting and measuring, in some objective way, the other possible outcomes of laboratory work. Our best guess was, of course, that these would be found in the skill and facility of handling apparatus or in the ability to do the manipulations required in the experiments which had served as lessons. The problem was then to determine; *first*, what skills and manipulations were required in the experimentation and, *second*, to devise objective measures of the students' ability to do them.

The first attempt to make a test of this character utilized the method which in vocational education and in curriculum studies is called the "job analysis method." We selected two experimental topics common to all general chemistry courses, namely, the preparation of oxygen and the preparation of hydrogen. Two competent teachers were asked, each separately, to go through the entire performance of each of these experiments, using the procedure and technic of manipulation which they would use for instruction of pupils. Three other teachers acting as observers made notes of the elements in the performances. From those items most frequently listed, a sequence of 20 items for each preparation was made which therefore represented the actual steps in the performance of the experiment. The list was mimeographed and constituted the scoring sheet for what we have called the Individual Performance Test. A copy of the test is here reproduced.

[2] This is essentially consistent with findings of Cooprider, Anibal, Cunningham, Carpenter; see summaries by Professor Elliot R. Downing, University of Chicago, in *Sch. Rev.*, **32**, 686–97 (Nov., 1925) and *Gen. Sci. Quart.*, **11**, 96–9 (Jan., 1927); and by Reidel, F. A., *Sch. Sci. & Math.*, **27**, 512–9 (May, 1927) and 620–31 (June, 1927).

Name..... Science Class.....Date.....

SCORING SHEET FOR INDIVIDUAL PERFORMANCE IN LABORATORY

*Preparation of Hydrogen:*

1. Selects zinc ——
2. Selects sulfuric or hydrochloric acid ——
3. Selects proper stopper and proper delivery tube ——
4. Selects pan and bottle ——
5. Puts water in pan ——
6. Fills bottle with water ——
7. Inverts bottle in pan covered with hand or glass ——
8. Puts delivery tube together in proper way ——
9. Twists or screws the stopper into the tube ——
10. Takes some zinc out in hand or on paper—does not pour into test tube ——
11. Slides zinc into tube with tube oblique ——
12. Takes stopper from bottle—between fingers ——
13. Dilutes the acid—must put water in first ——
14. Puts stopper back in bottle—not on table ——
15. Sets reagent bottles back on shelf before collecting gas ——
16. Inserts end of delivery tube beneath bottle without allowing air to enter ——
17. Removes bottle with cover on mouth ——
18. Sets bottle mouth *down* ——
19. Uses flame—not spark—to test gas ——
20. Pours out acid and saves zinc ——

*Preparation of Oxygen:*

1. Selects potassium chlorate ——
2. Selects manganese dioxide ——
3. Mixes substances on paper ——
4. Prepares delivery tube—correctly joined ——
5. Fills bottle with water ——
6. Puts water in the pan ——
7. Selects a dry test tube ——
8. Holds the test tube in a clamp of some kind ——
9. Inverts bottle in water with hand or glass over the mouth ——
10. Heats tube slowly at first by moving either the flame or the tube ——
11. Inserts delivery tube under bottle so that no air enters ——
12. When heat is stopped, removes delivery tube or stopper ——
13. Allows no water to suck back into tube ——
14. Removes bottle with cover over the mouth ——
15. Sets bottle mouth *upward* ——
16. Tests gas with spark—not with flame ——
17. Puts cover back on bottle after testing ——
18. Disconnects apparatus and replaces properly ——
19. Replaces all stoppers to bottles without laying them on the table ——
20. Uses creased paper or in some other way gets material into test tube without spilling ——

In administering this test individual pupils selected at random from the groups having individual laboratory work and those having demonstration work were tested by a single instructor examining one candidate at a time. Each candidate was given the same instructions from a typewritten form. Pupils were examined in this manner, of which number, after equating, there resulted a group of 73 laboratory trained pupils and 44 demonstration trained. These groups represented an equal number of samples from each teacher involved. As each pupil's examination required on the average ten minutes, the total time to gather the data was spread over a period

of two weeks. The reliability of the test itself is measured by the coefficient $r = 0.88 \pm 0.04$ and this is equivalent to an index of reliability of 0.94. Table II presents the data from this test.

TABLE II

RESULTS OF THE INDIVIDUAL PERFORMANCE TEST (NUMBER 1)

| | Dem. group | Indiv. group |
|---|---|---|
| No. of pupils | 44 | 73 |
| Mean score | 9.95 | 12.83 |
| Difference | | 2.88 |
| Sigma of diff. | | 0.58 |
| $\frac{\text{Difference}}{\text{Sigma (diff.)}} =$ | | 4.96 |

Some of the facts presented here should be noted as significant.

1. The difference in ability to *do* the experimentation is measured by 2.88 score points out of 20 and is in favor of the individually trained group.
2. The difference is statistically reliable—exceeding the requirements by 1.96 times sigma of difference.

Verification of this result was made the following year with another group of students and with a much more complete sampling of the manipulations of the general chemistry course. In this test the same technic of testing was used with 36 items involved, which items were validated by analysis of manuals and by the judgment of competent chemistry teachers, by a means to be described later. Fewer cases were examined in this testing but the time taken for each was longer and the test itself, with more items, has an even higher reliability than the first one. Table III presents the results of this test.

TABLE III

INDIVIDUAL PERFORMANCE TEST (NUMBER 2)

| | Dem. group | Indiv. group |
|---|---|---|
| No. of pupils | 12 | 26 |
| Mean score | 19.75 | 26.58 |
| Difference | | 6.84 |
| Sigma (diff.) | | 1.58 |
| $\frac{\text{Difference}}{\text{Sigma (diff.)}} =$ | | 4.32 |

Taken together, then, these tests of a non-written type in which the pupil is required to actually do the task he has been taught, give us reason to believe that the practice in the laboratory does yield outcomes which are measurable and which are superior to the outcomes from the demonstration method to a significant extent.

*Class Performance Test.*—Further verification was moreover sought and found by means of a class performance test. The task of individually examining pupils is great, so great that as a tool for measurement it is

too cumbersome for general use. We desired to devise a measure for a whole class which could be administered in a fifty-minute period. By analyzing the topics chosen for the test, but into a smaller number of items than in the individual performance, we partially solved the difficulty. Then, by using several examiners in the laboratory, who rated on a card held by each student the time and correctness of each item, we were able to accomplish the desired end. The first attempt with this technic was made with the groups in the rotation experiment. The topics, ammonia and oxides of nitrogen, which had been used in the instruction were analyzed into seven items. Each student held a card with his name, the time commenced, and a list of the seven items to be scored. On completion of each step the pupil raised his hand and the proctor immediately marked the time of completion of the task if it was correctly done. If incorrectly done he marked the task zero. The scores from these cards were tabulated in terms of correctness, of speed, and of the combined speed and correctness. From these data it was found that the group having had training by the individual method with directions excelled the demonstration group in general efficiency by a difference in the means of 20.57 score points; and with a reliability of this difference measured by 3.19 times the sigma of the difference. This may be interpreted as a significant difference. The results confirm the results of the individual performance tests.

From this evidence, then, it may be said with some assurance that, in the school situation here portrayed, the method of doing experiments in the laboratory individually, following printed directions, does result in ability to repeat the manipulations and to use them to *do* actually—not tell about them—and that this ability is not gained to a like extent by passively watching the teacher demonstrate the experiments.

*Manipulative Technic.*—The question next arose, how important in chemistry are these manipulations which have been used in these performance tests? To arrive at an acceptable answer, the writer undertook the task of analyzing 16 widely used laboratory manuals for the items of manipulation involved in doing the experimentation required in the first course in chemistry. This list proved to contain 108 items. Then the judgment of eighteen well-known authorities in chemical education, as to the importance of these items, was secured by a questionnaire. This judgment evaluated the skill and habits called for and showed that, of the 108 items, 55 were considered of sufficient importance to be included as desirable model technics to be given to all students; while 35 were judged of such importance that they should be classed as "habits" desirable for pupils to acquire.

Two repeated tests of the difficulty of these manipulations were given to two sets of pupils; one group had had one term of chemistry and the other, a class in biology, had had no training in chemistry. These

tests showed that 50% of the pupils were able to do 80% of the manipulations with one practice period after the pattern was demonstrated by the teacher. This seems to indicate that the skill required in the laboratory work is not great and that the pupils at the high-school level possess, without further training, the manual dexterity to do the manipulations readily. All they appear to need is a precise mental picture of the technic, gained by watching the teacher, and one or more opportunities to practise. Demonstration alone is not sufficient to give the ability to do the manipulations when called upon, and much less to insure the recall of the proper technic as a habitual response when confronted with a task requiring it. Practice is required, as we should expect, but this practice appears to be less than might be supposed. If in 18 exercises (*i. e.*, 18 weeks of one laboratory period per week) the habits are acquired, so that, on the average, 80% of them function when the repetition of previously performed experiments requires them, it seems fair to say that the manipulations are not inherently difficult and that little practice is necessary to acquire them.

*Questionnaire Relative to Individual Laboratory Work versus Demonstration.*—Finally, to complete the picture of what our practices were doing in this science department, a series of questions was proposed to the first-term students as a supplement to their mid-term examination. The purpose was to get first-hand information as to how the pupils reacted toward laboratory work. The questions were worded so as to suggest some of the alleged shortcomings of the methods and to secure a check on each answer by means of another differently worded question. An inspection of the questions which appear in Table IV will reveal the purpose and the method. The answers are consistent, on the whole, lack of consistency being probably a result of ambiguous or faulty wording rather than of uncertainty in the pupil's opinion. Even if we discount the figures because of docility of pupils and unwillingness to express an opinion contrary to what appeared to be the "vogue," the results seem, nevertheless, to be consistent with the views of teachers themselves. Segerblom[3] in the result of a questionnaire found that 93 teachers out of 95 expressed the opinion that chemistry could not be taught without individual laboratory work. These teachers represented ninety-five schools in New England; and while this expression may not be generalized to stand for all sections of the country—Missouri, for instance—it is the deliberate opinion of an organization for which we all have the highest respect.

The results from the questionnaires to teachers and to pupils show only *opinion*. This opinion, however, in the case of pupils, involves an attitude toward the work which we have need to utilize. Motivation, at least,

[3] Segerblom, Wilhelm: "Report of the Committee to Investigate Laboratory Practices in Chemistry," *Report, N. E. A. C. T.* Twenty-fifth Ann. No., Malden, Mass., 1924.

results from it, and with the limited opportunities in city life for expression and outlet for native physical impulses to activity, this slight offering of one period per week may fill a real need in the pupils' lives. This suggestion is, of course, an hypothesis arising from the pupils' apparent liking for laboratory work and not an inference based on any evidence here presented. Yet this phase of the question deserves careful consideration before we dispose of the matter.

TABLE IV

QUESTIONNAIRE TO PUPILS REGARDING THEIR PREFERENCES FOR INDIVIDUAL LABORATORY WORK AND DEMONSTRATION WORK

| Questions to be answered (To be answered by yes or no) | Number Yes | Number No | Per cent Yes | Per cent No |
|---|---|---|---|---|
| 1. I enjoy doing laboratory work more than watching the experiment performed by the instructor | 296 | 43 | 87.3 | 12.7 |
| 2. I understand the experiment better when the teacher performs it than when I do it myself | 159 | 180 | 46.9 | 53.1 |
| 3. The performing of experiments in the laboratory is so mussy and so harmful to the hands and clothes that I prefer to have the teacher demonstrate all the experiments | 86 | 253 | 25.3 | 74.7 |
| 4. I would prefer to have the whole chemistry course based on the observations made in the laboratory and in demonstrations, rather than to use a textbook for study on two days a week | 145 | 194 | 42.7 | 57.3 |
| 5. I think that every student should have a textbook and that I can learn more chemistry by having lessons assigned in the textbook two days out of five than if I had to depend on my observations entirely | 215 | 124 | 63.4 | 36.6 |
| 6. I prefer to learn all the chemistry from the textbook rather than have any demonstrations or experiments | 12 | 327 | 3.6 | 96.4 |

## Summary and Conclusions

The facts we have reported in this article have been assembled from a much larger mass collected in the study. From them we get the following picture of the situation in terms of present practices:

1. Individual laboratory work and demonstration work, when given one day in five, show little difference in their effects upon pupils' ability to succeed in written tests.

2. Written tests are unsatisfactory or at least incomplete instruments for measuring such abilities as do result from laboratory work.

3. Non-written tests consisting of manipulative exercises of the course, analyzed into items for scoring, can be devised to measure these abilities.

4. Such non-written manipulative tests do detect differences between the outcomes of the individual work and the outcomes of demonstration work.

5. The individual laboratory work, following directions from a manual and given once per week (one-fifth of the total class time), results in greater

ability to do the manipulations and experiments taught than the demonstration method.

6. The manipulations as ordinarily given in the directions from the manuals comprise not less than 108 items in the first-year course in chemistry.

7. These manipulations are apparently simple and so easy to learn that the average of a beginning class can do 80% of them after one practice period following a model set by the teacher. For habits, more practice is needed.

8. The pupils themselves prefer the individual laboratory work to the demonstration work by a vote of about nine out of ten.

In the light of this evidence, how shall we answer our original query about laboratory work? Shall we give more or less? It appears that, after all, the question depends now upon what use is expected to be made of the chemistry, and with that question this study has nothing to offer. Yet while on the basis of these facts what shall be required cannot be decided, we have shown what the respective methods are capable of doing. Demonstration, it appears, can present, almost, if not quite as effectively, those experiences which serve as information and for making verbal answers to verbal questions in written tests. If this information is all we set up as a goal; if a passing acquaintance with the phenomena of chemistry, sufficient to understand written articles of a popular nature, or ability to interpret elementary chemical discussion is all that is desired, it would seem that the demonstration method adequately and much more economically, as regards both time and materials, meets the requirements. Curriculum studies may show this to be the case; certainly there are worthy advocates of this view. However, if further work in the field of chemistry or other science, is to be done in college or technical school laboratories, pupils will doubtless find themselves handicapped unless they have had some practice in the individual laboratory work. Whether either of the methods has actual or potential outcome in terms of transfer to other fields of activity may not be inferred from these data. In a subsequent article the writer will present some other facts which may have a bearing on this aspect of the problem.

Thus it appears that the vexing problem of demonstration versus individual laboratory work is not susceptible of a categorical, hard and fast answer; but involves a thorough understanding of the needs of the pupils in the light of what they will in all probability do after they leave high school. However, it appears from the results in this school that we must not expect individual laboratory work, following directions as in the traditional practice, to yield superior returns commensurate with the outlay of time and money, in terms of the outcomes measured by the written examinations. On the other hand, we may not expect ability

to do chemical experimentation itself merely from watching the teacher; but rather from some practice in actual manipulation by individual laboratory work. It should be noted that this study establishes that certain outcomes may be obtained from the application of individual laboratory work. But the significance of these outcomes may be evaluated only in terms of curriculum values.

These generalizations are inferred from the preliminary evaluation of the traditional practices as briefly described in this report of experimentation. They do not represent a final answer nor yet the writer's own evaluation of the potential functions of demonstration and individual laboratory work. In another article, an experimental study of certain modifications of the traditional use of the laboratory will be reported. In this experimentation a somewhat abrupt breaking away from traditional practice was undertaken. The results seem to point toward a reconsideration of the question, and offer at least the possibility of an approach to some satisfying answers.

In summary, it appears from the data that it is quite in vain to attempt to gain a preference for one or the other of the methods of demonstration or individual laboratory procedure. Shall we not rather consider them both as potential means for accomplishing a part of our task? Shall we not seek to utilize in each those outcomes which have been found and measured? Should not our further efforts and attention be directed toward a search for means to utilize to the full the indicated possibilities of each method? Is it not, therefore, an implication of the facts here presented that we should seek to make the laboratory and the demonstration complementary and mutually helpful, and let both contribute to making chemistry not only a preparation for more chemistry but a means of achieving our larger task, namely, the training of thoughtful men and women who not only *know* but *are able to do?*

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**Synthetic Nitrate Plant in Holland.** The Netherlands are to have their synthetic nitrate plant as an adjunct to the Koninkijkle Nederlandsche Hoogovens en Staalfabriek, according to the Department of Commerce.

The addition of a nitrogen plant to their iron and steel works in Ijmuiden, Netherlands, by the Koninkijkle Nederlandsche Hoogovens en Staalfabriek, will constitute the first factory for the manufacture of artificial nitrates in the country, according to a report from Consul Pattie H. Field.

The work is expected to begin immediately, under a separate corporation which is to be created for the administration of the new industry. The new factory will be equipped to manufacture ammonia by separating hydrogen from coke oven gas and combining this synthetically with nitrogen from the air, thus making possible a large production of artificial fertilizer, which commodity has hitherto been imported from Germany and Chile.—*Chem. Markets*, **23**, 212 (Aug., 1928).

# A GRAPHIC METHOD FOR SOLVING SIMPLE STOICHIOMETRIC PROBLEMS

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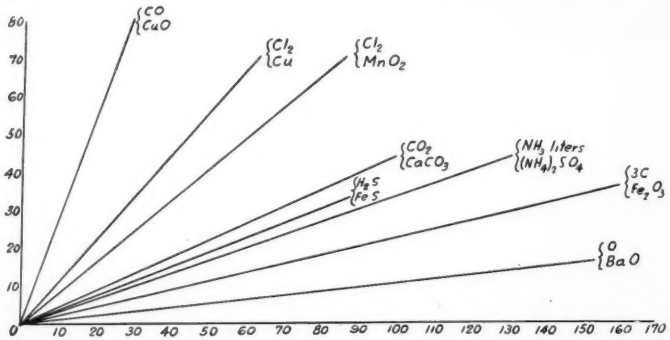
While the usual method for solving problems in stoichiometry is the best and only method which should be taught to high-school students, it often involves tedious computations. Teachers of elementary chemistry may like to learn of an interesting variant for the solution of such problems.

On a sheet of cross-section paper, ruled in tenths, choose a point of origin in the lower left-hand corner and through this point draw two lines at right-angles. Find next the values concerned in the problem as, for example, 87 grams of manganese dioxide will liberate 71 grams of chlorine from hydrochloric acid. Locate the point 87-71 as is customary in analytical geometry. From this point draw a line to the origin. Now any point on this line will mark the intersection of two perpendiculars, one drawn from a position on the ordinate representing a given value, and the other




drawn to a point on the abscissa representing the corresponding value of the answer. For example, using the accompanying chart, let us solve the problem: "How many grams of hydrogen sulfide can be produced by the action of acid on 50 grams of ferrous sulfide?" The values concerned are 34 and 88. Locate the point as shown.

If the answer is to be found in liters, the procedure is the same. "How many liters of ammonia gas can be produced by the action of slaked lime on 40 grams of ammonium sulfate?" The values concerned are 132 and 44.8. Locate this point and draw the line to the origin. For 40 grams of the sulfate the corresponding value in liters of ammonia is 13.5 liters.

It is perhaps unnecessary to remark that the accuracy of the results obtained by the use of the above method will depend to a very large extent upon the accuracy with which the chart is drawn.

# TERM PAPER PRACTICES IN TEACHING CHEMISTRY IN THE HIGH SCHOOLS OF THE UNITED STATES

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A questionnaire study of term paper practices in teaching chemistry in the high schools of the United States was made because of the apparent lack of source material on this particular subject. The purpose of the study was to gather information concerning the frequency, length, and type of written and oral reports required in high-school courses in chemistry. A brief questionnaire was sent to five high schools in each state. These schools were chosen as representative, both in size and location. From the 240 schools, 89 replies were received. We believe that we are justified in drawing conclusions from the data obtained and in considering those conclusions applicable to the country as a whole, since schools with a total enrolment of 82,149 pupils and located in 43 states contributed information included in this study.

The information relating to the size of the 89 schools and their chemistry departments is as follows:

| | Range | Average | Total |
|---|---|---|---|
| Enrolment of schools studied | 80–3000 | 923 | 82,149 |
| Chemistry department enrolment | 7–500 | 79 | 7,016 |

The percentage of students enrolled in courses in chemistry varied from 3 per cent at Mobile, Alabama, to 28.5 per cent at Selma, Alabama, with an average percentage of 8.5 per cent in the 89 schools studied.

The following facts were obtained regarding the frequency and length of the written and oral reports required:

| | Written | Oral |
|---|---|---|
| Schools requiring | 47 (52.8%) | 66 (74%) |
| Schools not requiring | 42 (47.2%) | 23 (26%) |
| Range in number per year | 1–8 | |
| Average number per year | 2+ | |
| Range in length | 100–2500 (words) | 5–30 (min.) |
| Average length | 1160 (words) | 10 (min.) |

It is interesting to note that in all of the 47 schools requiring written term papers, industrial topics were used. Household topics were next in popularity with 40 out of the 47 schools, and technical topics were used in 29 instances. Of the 66 schools using oral reports the instructors in 24 instances (36.3%) specified the topics to be used. In 12 cases (18%) the pupils selected the topics. In 30 classes (45.7%) the topics were selected from an approved list.

In reply to the question, "In your opinion what are the benefits obtained?" the following answers were obtained:

1. Adds interest and enriches the course.
2. Broadens viewpoint of the subject.
3. Emphasizes application to every-day life.
4. Familiarizes student with library.
5. Encourages and aims toward efficiency in research work.
6. Broadens pupil's imagination.
7. Associates class work with environment.
8. Gives pupil opportunity to follow his own interest.
9. Develops ability to stand before class and talk.
10. Gives better understanding of theory through application.
11. Encourages student to continue study of chemistry.
12. Keeps students alert for magazine articles.
13. Improves student's method of organization and presentation.
14. Creates greater sympathy in all projects involving science.

A number of added comments were given, and are included in this report with the idea that they may be helpful to others requiring such reports. Recognition was given in many cases to the American Chemical Society Prize Essay Contest, and students writing essays for this contest were usually excused from other similar requirements. In one case the instructor mentioned giving extra grades for written and oral reports rather than requiring them. The point system was also suggested where students were required to complete a certain number of points per year in term paper reports, readings, and projects. One instructor encourages "reading for pleasure, rather than as a task to perform."

Care must be exercised in drawing conclusions from the data received. The schools are nearly equally divided on the use of written term reports with a slight preference for their use. Most schools operate upon a semester plan and, therefore, require, as expected, two papers per year. The most outstanding fact to be observed is that oral reports are far more popular than the usual formal written reports. If the American Chemical Society Prize Essays were eliminated the difference would be even greater. It was not the original purpose of this study to justify either written or oral reports but merely to study prevailing practices and a careful study by statistical methods would be necessary to evaluate the real worth of such reports.

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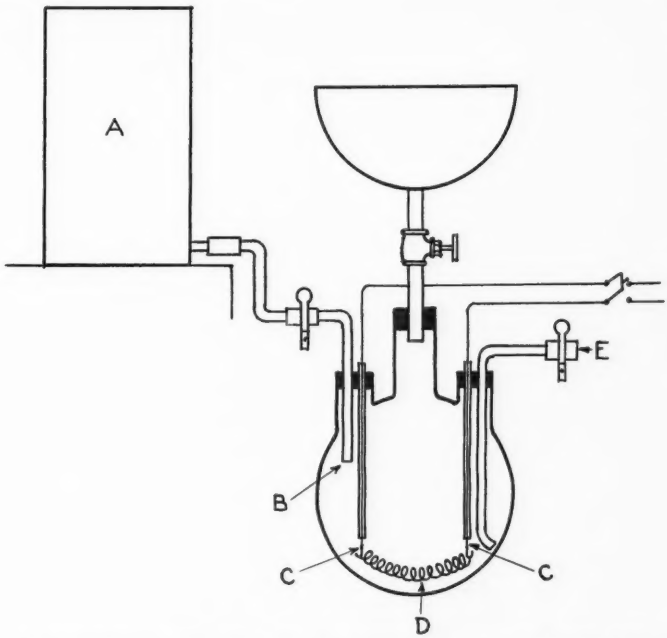
**Chlolesterol Used to Prevent Rickets.** Evidence suggesting that ergosterol is not the only substance that can be given the power to prevent rickets by exposure to ultra-violet light was presented to the Institute of Chemistry of the American Chemical Society recently by Mrs. Elizabeth M. Koch of the University of Chicago.

A commercial cholesterol, a substance found in nerve tissue, egg yolks, and blood, was exposed to ultra-violet light. It acquired the power of preventing rickets to a high degree, proving about one-seventy-fifth as effective as ergosterol, which has a very high anti-rachitic potency. When the commercial product was purified its potency was not nearly so great, but heating the purified product in nitrogen under pressure raised the potency to its original degree.—*Science Service*

# AN ELECTRIC STEAM-BATH[1]

GILES B. COOKE, UNIVERSITY OF MARYLAND, COLLEGE PARK, MARYLAND

In laboratories not equipped with steam the distillation of volatile, inflammable solvents is very inconvenient and often hazardous. With such a substance as ether, hot water is the only recourse. The hot plate may be used with higher boiling and less inflammable liquids, such as alcohol, but it is far from satisfactory. With such solvents distillation should be accomplished by steam.




*A*—Reservoir; *B*—Water inlet; *C*—Copper wire; *D*—Heating coil; *E*—Outlet for draining flask.

A steam-bath can easily be constructed for such purposes. An electric current is passed through a coil of resistance wire which has been placed in a three-neck three-liter flask and covered with water. For 110 volts, six feet of wire are used. The wire is coiled by winding it around a pencil or stirring rod. It is convenient to keep the flask from one-half to three-

[1] No originality is claimed for the devising of this steam-bath. It is simply offered by the writer for any value it may have.

(*Concluded on page 1463*)

# THE AMERICAN FIELD SERVICE FELLOWSHIPS

ARCHIE M. PALMER, INSTITUTE OF INTERNATIONAL EDUCATION, NEW YORK CITY

With the traditional background provided by the outstanding achievements of Lavoisier, Gay-Lussac, Berthelot, and Pasteur it is not at all surprising that France should attract young American scientists and most particularly those in the field of chemistry. It was in order to develop a more complete realization and consideration of the contributions made by these great minds and by other French savants to science and learning that an organization known as the American Field Service Fellowships for French Universities was established shortly after the World War. It was also "in order to provide an enduring memorial to the one hundred and twenty-seven Field Service men who gave their lives to the cause and to perpetuate among future generations the mutual understanding and fraternity of spirit which marked their relations during the war" that the organization has continued its activities.

Each year awards are made of a series of Fellowships for advanced study in France to qualified candidates selected from among the graduates of American colleges and universities and from the technical and industrial field. A limited number of these Fellowships are available for the year 1929–30. Each will carry a stipend of $1200 and will be tenable for one year. A Fellowship may be renewed for a second year upon application provided circumstances warrant it.

In general, these Fellowships are offered in the following fields of study: agriculture, anthropology, archaeology and history of art, architecture, astronomy, biology, botany, chemistry, classical languages and literature, criminology, economics, education, English language and literature, geography, geology, history, law, mathematics, medicine and surgery, oriental languages and literature, philosophy, physics, political science and international law, psychology, religion, Romance languages and literature, Semitic languages and literature, Slavic languages and literature, sociology, zoölogy. A candidate may choose the field of study he prefers but usually the Fellowships will only be granted for the pursuit of advanced study in the field in which the candidate has shown proficiency.

The fellowships are offered for study in the universities and faculties and other institutions of higher learning in Paris and in the sixteen provincial universities. The candidate may designate his choice of the institution in which to pursue his work but the desirability of a period of residence in a provincial university is strongly recommended.

The fellowships are open at present only to men. A candidate must be a citizen of the United States or of one of its possessions. He must at the time of making application be a graduate of a college of recognized standing or of a professional school requiring three years of study for a degree;

or, if not qualified in either of these ways, must be twenty-four years of age and must have spent five years in work requiring high technical skill. He must be of good moral character and intellectual ability, of suitable personal qualities, and must have a practical ability to use French books, both in general subjects and in his own special field, and be able to speak French and understand lectures delivered in French.

Applicants who accept the award of a fellowship are expected to sail for France on or about July 1, or preferably earlier, in the year in which the award is made. Unless already so proficient in the language as to be exempt from this requirement they are required to devote the first summer to the study and practice of oral French. It is strongly recommended that in such cases the first few months be spent in the provinces, where experience indicates that the most rapid progress can be made in learning the language.

Rich opportunities in every field of study and research are afforded in the universities of France to American students. The graduate of an American college who desires to proceed to an advanced degree will find that a French university degree equivalent in standing to the Ph.D. of an American university of recognized standing and declared by the French university authorities to have the same scientific and academic value as the state doctorate (doctorat d'État) can now be obtained in all of the faculties of the University of Paris and at all of the other sixteen French universities, while opportunities for study in the specialized national and independent institutions are also available to him.

Applications must be filed not later than January 1st of the year in which the award is to be made. Full information and application blanks may be obtained by addressing the Assistant Director of the Institute of International Education, 2 West 45th Street, New York, N. Y.

These opportunities have always been very popular with advanced students in the field of chemistry. As is to be expected, a large percentage of the candidates apply in the field of Romance languages and literature. The next largest number in most years has come from the field of chemistry, and a year has not passed when there has not been at least one candidate selected from that field.

It is of particular interest to those in the field of chemistry that one member of the original group of eight fellows who was selected in 1919, Dr. Albert W. Noyes, Jr., won the distinction of being the first American student to obtain the doctorat és Sciences (d'État) with his thesis on "Polarization in Iron Solutions." He returned to the United States in 1920 to accept an appointment at the University of California and he is now an assistant professor at the University of Chicago.

# DOCTORATES IN CHEMISTRY CONFERRED BY AMERICAN UNIVERSITIES, 1927–1928

COMPILED BY CALLIE HULL AND CLARENCE J. WEST, RESEARCH INFORMATION SERVICE, NATIONAL RESEARCH COUNCIL, WASHINGTON, D. C.

Continuing the compilation which has appeared in THIS JOURNAL for the past three years [**3,** 77–99 (1926); **4,** 99–109; 1303–13 (1927)], the Research Information Service of the National Research Council offers the following statistics of doctorates in chemistry conferred by American universities during the academic year 1927–1928.

In this compilation, the doctorates granted by the Universities in engineering or metallurgy have been listed separately, and also those granted in physiology which are of chemical interest. These are included with those granted in chemistry in the statistical tables.

The universities granting ten or more doctorates in chemistry during the past year show certain changes; California, Ohio State, Harvard, and Pittsburgh have given place to Iowa, Minnesota, and Iowa State College. Such variations in the number granted occur every year and probably have no real significance, although it is interesting to note that only two of the fifteen universities which have conferred ten or more during the nine years for which statistics are available have not once fallen below that number. These are Chicago and Johns Hopkins.

A fairly representative picture of chemical research in the universities of the United States is presented through the statistics on graduate students in chemistry in the United States [THIS JOURNAL, **5,** 882–4 (1928)], the survey of the support of graduate research in chemistry [*Ibid.*, **5,** 1005–14 (1928)], and the statistics given in this compilation. As the first and last of these compilations appear annually, the growth in chemical research in universities may be followed by those interested.

TABLE I

DISTRIBUTION OF DOCTORATES IN CHEMISTRY BY UNIVERSITY, BY YEAR

| | '19–'20 | '20–'21 | '21–'22 | '22–'23 | '23–'24 | '24–'25 | '25–'26 | '26–'27 | '27–'28 |
|---|---|---|---|---|---|---|---|---|---|
| American | .. | .. | .. | .. | .. | .. | 1 | 1 | 1 |
| Boston | .. | .. | .. | 1 | .. | .. | 1 | .. | .. |
| Brown | 1 | 1 | .. | .. | .. | 5 | 2 | 2 | 4 |
| Bryn Mawr | .. | .. | 1 | .. | .. | .. | .. | 1 | .. |
| California | 3 | 6 | 8 | 11 | 6 | 8 | 7 | 16 | 9 |
| Calif. Inst. Tech. | 1 | .. | 2 | .. | 3 | 4 | 7 | .. | 6 |
| Catholic | .. | .. | .. | 1 | 2 | 2 | 1 | 3 | 1 |
| Chicago | 13 | 16 | 14 | 12 | 19 | 14 | 26 | 21 | 19 |
| Cincinnati | 1 | 2 | 3 | 1 | 2 | 4 | 4 | 3 | .. |
| Clark | 2 | 3 | 2 | 3 | 3 | .. | .. | .. | .. |
| Colorado | .. | .. | 1 | 1 | .. | 1 | 2 | 1 | 3 |
| Columbia | 8 | 18 | 13 | 28 | 35 | 30 | 34 | 28 | 23 |

TABLE I (*Concluded*)

| | '19–'20 | '20–'21 | '21–'22 | '22–'23 | '23–'24 | '24–'25 | '25–'26 | '26–'27 | '27–28 |
|---|---|---|---|---|---|---|---|---|---|
| Cornell | 3 | 8 | 9 | 8 | 19 | 14 | 12 | 16 | 21 |
| Fordham | 1 | .. | 2 | 2 | .. | 2 | 2 | 1 | 2 |
| George Washington | 3 | 1 | .. | 6 | 3 | 1 | 2 | 2 | 1 |
| Harvard | 4 | 5 | 3 | 5 | 18 | 13 | 10 | 11 | 8 |
| Illinois | 8 | 7 | 16 | 19 | 19 | 18 | 18 | 11 | 16 |
| Indiana | .. | .. | 1 | 2 | 1 | 2 | 2 | 2 | 2 |
| Iowa | .. | .. | .. | 4 | 3 | 6 | 10 | 9 | 16 |
| Iowa State | .. | .. | .. | .. | 4 | 7 | 8 | 7 | 13 |
| Johns Hopkins | 10 | 10 | 13 | 12 | 12 | 10 | 19 | 15 | 17 |
| Kansas | .. | .. | .. | .. | 1 | 3 | 1 | 5 | 3 |
| Maryland | .. | .. | .. | .. | .. | .. | 4 | 2 | 3 |
| Mass. Agri. Coll. | .. | .. | .. | 1 | .. | .. | .. | .. | .. |
| Mass. Inst. Tech. | 4 | 6 | 5 | 6 | 11 | 17 | 8 | 6 | 7 |
| Michigan | 2 | 6 | 5 | 2 | 11 | 2 | 13 | 8 | 8 |
| Mich. State Coll. | .. | .. | .. | .. | .. | .. | 1 | .. | .. |
| Minnesota | .. | .. | 5 | 3 | 9 | 8 | 8 | 8 | 15 |
| Missouri | .. | .. | .. | .. | 1 | 1 | 1 | 1 | 2 |
| Nebraska | .. | 1 | 1 | 1 | 3 | 3 | 1 | 1 | .. |
| New York | 1 | 3 | 1 | 6 | 1 | 3 | 2 | 3 | 6 |
| New York State Coll. For. | .. | .. | .. | .. | .. | .. | .. | .. | 1 |
| North Carolina | .. | 2 | 1 | 1 | .. | .. | 5 | 2 | 4 |
| Northwestern | .. | .. | 4 | .. | 4 | 1 | 1 | 3 | 5 |
| Notre Dame | 1 | .. | .. | 1 | 2 | .. | .. | .. | .. |
| Ohio State | 2 | 5 | 4 | 13 | 14 | 23 | 11 | 15 | 11 |
| Pennsylvania | .. | 1 | 3 | .. | 4 | 1 | 7 | 7 | 3 |
| Pittsburgh | 1 | 2 | 5 | 6 | 5 | 7 | 3 | 10 | 9 |
| Princeton | 3 | 5 | 5 | 2 | 8 | 4 | 4 | 4 | 8 |
| Radcliffe | .. | 1 | .. | .. | .. | .. | .. | .. | 1 |
| Rensselaer | .. | .. | .. | .. | .. | .. | .. | .. | 3 |
| Rice | .. | 1 | .. | .. | .. | 1 | .. | 1 | 1 |
| Rutgers | .. | .. | .. | .. | .. | .. | .. | .. | 1 |
| St. Louis Univ. | .. | .. | .. | .. | .. | .. | .. | 2 | 1 |
| Stanford | .. | 2 | 1 | 3 | 8 | 2 | 5 | 3 | 3 |
| Syracuse | .. | .. | .. | .. | .. | .. | .. | 2 | 1 |
| Tulane | .. | .. | .. | .. | .. | .. | .. | 1 | .. |
| Virginia | 1 | .. | 1 | 1 | 2 | 3 | 2 | 3 | 2 |
| Wash. Univ., St. Louis | .. | .. | .. | 1 | .. | .. | .. | 2 | .. |
| Washington | .. | 1 | 2 | .. | 1 | 2 | .. | 1 | 1 |
| Wisconsin | 8 | 9 | 13 | 14 | 21 | 26 | 24 | 16 | 25 |
| Yale | 12 | 13 | 13 | 17 | 8 | 16 | 18 | 12 | 19 |
| TOTAL | 93 | 135 | 157 | 194 | 263 | 264 | 287 | 268 | 287 |

TABLE II

UNIVERSITIES GRANTING 10 OR MORE DOCTORATES IN CHEMISTRY, 1927–28

| | '20–'21 | '21–'22 | '22–'23 | '23–'24 | '24–'25 | '25–'26 | '26–'27 | '27–'28 |
|---|---|---|---|---|---|---|---|---|
| Wisconsin | 9 | 13 | 14 | 21 | 26 | 24 | 16 | 25 |
| Columbia | 18 | 13 | 28 | 35 | 30 | 34 | 28 | 23 |
| Cornell | 8 | 9 | 8 | 19 | 14 | 12 | 16 | 21 |

TABLE II (*Concluded*)

| | '20–'21 | '21–'22 | '22–'23 | '23–'24 | '24–'25 | '25–'26 | '26–'27 | '27–'28 |
|---|---|---|---|---|---|---|---|---|
| Chicago | 16 | 14 | 12 | 19 | 14 | 26 | 21 | 19 |
| Yale | 13 | 13 | 17 | 8 | 16 | 18 | 12 | 19 |
| Johns Hopkins | 10 | 13 | 12 | 12 | 10 | 19 | 15 | 17 |
| Illinois | 7 | 16 | 19 | 19 | 18 | 18 | 11 | 16 |
| Iowa | .. | .. | 4 | 3 | 6 | 10 | 9 | 16 |
| Minnesota | .. | 5 | 3 | 9 | 8 | 8 | 8 | 15 |
| Iowa State | .. | .. | .. | 4 | 7 | 8 | 7 | 13 |
| Ohio State | 5 | 4 | 13 | 14 | '23 | 11 | 15 | 11 |

## CHEMISTRY

### American

LOUIS WILSON MATTERN, "Chemistry in College Entrance and Graduation Requirements."

### Brown

EDWARD SEATON CARNEY, "The Preparation, Properties and Some Reactions of Sodium Germanyl." HOWARD STERLING NUTTING, "I. Reactions of Sodium Triphenyl Germanide with Halogenated Methanes in Liquid Ammonia. II. Preparation of Phenyl Boron Halides by Means of the Grignard Reagent and Boron Trifluoride." HARRY HOWARD REYNOLDS, "A Study of Some Organic Silicon Compounds." CHARLES BUSHNELL WOOSTER, "I. Some Triphenylgermanium Derivatives. II. The Conductance of Sodium Triphenylstannide and Analogous Salts in Liquid Ammonia."

### California

HENRY EYRING, "A Comparison of the Ionization by, and Stopping Power for, Alpha Particles of Elements and Compounds." HENRY SORG FRANK, "A New All-Glass Manometer and Its Application to a Problem in Adsorption." BERNARD SUTRO GREENSFELDER, "The Specific Heat and Entropy of Cesium Alum from 17° to 300° Absolute. The Electrode Potential of Aluminum from Thermal Data. The Entropy of Aluminum Ion." ROY WENDELL HARKNESS, "The Ionization of Carbon Monoxide by Electron Impact as Interpreted by Positive-Ray Analysis." PAUL L. KIRK, "Studies on the Behavior of Sodium and Barium Amalgam Electrodes in Solutions of Certain Amphoteric Substances." JEROME LEANDER MARTIN, "The Oxidation of Hydrazine." JOSEPH EDWARD MAYER, "The Influence of Radiation on Thermal Unimolecular Reactions." FREDERICK DOMINIC ROSSINI, "Heat Capacities in Aqueous Salt Solutions." BENJAMIN SOSNICK, "Thermodynamics of Gaseous Solutions."

### California Institute of Technology

WARREN PHELPS BAXTER, "Activation of Molecular Hydrogen by Electron Impact. Quantum Yield in the Photochemical Decomposition of Nitrogen Dioxide. Mechanism of the Photochemical Decomposition of Nitrogen Pentoxide." ARNOLD ORVILLE BECKMAN, "The Photochemical Decomposition of Hydrogen Azide." ROBERT HENNAH DALTON, "Activation of Molecular Hydrogen by Electron Impact. Velocity Distribution of Electrons Issuing from Small Holes. Activation of Gases by Electron Impact." MARTIN EMERY NORDBERG, "The Decomposition of Ozone-Nitrogen Pentoxide Mix-

tures." HAROLD HEIGES STEINOUR, "The Potential of Inert Electrodes in Sulfurous Acid Solutions." WILLIAM URE, "A Test of the Radiation Hypothesis of Chemical Reaction."

### Catholic

LEO PAO LEONG WOO, "The Adsorption of Mixtures of Highly Condensible Gases by Titania Gel."

### Chicago

HILMEYER COHEN, "The Dihydroxybutyrolactones. I. *dl*-Erythrolactone from $\Delta^1$-Crotonolactone; *dl*-Erythrolactone and *dl*-Threolactone from Vinylglycollic Ester." JAMES BERNARD CULBERTSON, "A Study of Tautomerism of Aromatic Ketimines." BENJAMIN BALL FREUD, "I. The Shapes of Hanging and Detaching Drops. II. A Balance for the Measurement of Film Pressures." OSCAR MARVIN HELMER, "A Study of Trypsin and Its Activation by Enterokinase." WESLEY NORMAN HERR, "The Quantum Efficiency of the Photochemical Decomposition of Anhydrous Formic Acid." JOSEPH SKEAN HICKS, "I. A Study of the Behavior and Structure of Sodium Copper Derivatives of Oxamide, Biuret and Malonamide. II. Determination of Small Quantities of Water in Methyl Alcohol." LOUIS STEVENSON KASSEL, "I. An Investigation of the Quantum Efficiency of the Decomposition of Ammonia at Very Short Wave-Lengths. II. On Homogeneous Unimolecular Gas Reactions." GEORGINE ADOLPH MOERKE, "A Study of the Biuret Reaction as Shown by Substituted Oxamides and Malonamides." ARTHUR EDWARD REMICK, "The Velocity of Saponification of Methyl and Ethyl Formates." DAVID NATHANIEL RICKLES, "Studies in Complex Amines. II. The Preferential Removal of Bromide Ion from the Coördination Sphere." FELIX WADSWORTH SAUNDERS, "A Study of the Combinations between Dyes and Proteins by Optical Methods."

### Colorado

INEZ HAM MATTISON, "The Rate of Elimination of Administered Urea as a Test of Kidney Function." OSCAR BRAUER MUENCH, "Lithium Platinocyanide and a Micro Method for the Quantitative Determination of Its Hydrates." DZU-KUN SHEN, "Photographic Sensitivity and the Latent Image."

### Columbia

JOSEPH HERMAN AXTMAYER, "A Quantitative Study of the Problem of Multiple Nature of Vitamin B." HATTIE LOUISE CAMPBELL, "Growth, Reproduction and Longevity of Experimental Animals as Research Criteria in the Chemistry of Nutrition." GEORGE HERBERT CONNITT, "A Study of Some of the Reactions of 6-Amino-*m*-Cresol." PAUL LOUIS DAY, "The Relative Stability of Vitamin A from Plant and Animal Sources." LOUISE DURAND, "A Study of the Quantitative Determination of Tungsten." WILLET LAWRENCE ECCLES, "Studies of the Corn Amyloses. III. The Isolation of Corn Gamma-Amylose." LUCIA EOLA EDSON, "A Physico-Chemical Study of Pectin." ISRAEL GOLDSTEIN, "Derivatives of 5-Acetocarvacryl Methyl Ether; Relation between Molecular Structure and Odor of 1,2,4,5-Substituted Benzenes." EDMUND HENRY HAMANN, "The Relation between Structure and Odor in Derivatives of Beta-Phenylethyl Alcohol." HELEN HAURY KINTZI, "A Quantitative Study of the Influence of Acetate and of Phosphate on the Activity of Malt Amylase." RALPH KURZROK, "Biochemical Studies of Human Semen and Its Relation to Mucus of the Cervix Uteri." HARDY WILLIAM LARSON, "A Study of the Relationship between Velocity of Hydrolysis of Sucrose by Invertase and Sucrose Concentration." YUN

HUA LI, "A Theory of Tanning Based upon the Study of Tanning Effects of Naphthalene Derivatives." FLETCHER LOW, "A Study of the Stability of Bredig Gold Sols." BISHAN NARAIN MATHUR, "Theory of Oil Tannage." EDWARD HUGHES MILLER, "The Influence of Hydrogen-Ion Activity upon Stability of Vitamin A." HERBERT RIVINGTON PYNE, "A New Apparatus for Determining Gas Solubilities." ANDREW CARL RICE, "A New Method for the Gravimetric Determination of Uranium." FREDERICK AUGUSTUS STENBUCK, "Studies on the Purification of Antibodies." ELTON BRINK TUCKER, "Removal of Sulfur Compounds from Petroleum Naphthas by Catalytic Decomposition with Bauxite."

**Cornell**

NICHOLAS BACON, "Vulcanization of Rubber." SEYMOUR WILSON BRAINARD, "The Detergent Action of Soap." PETER PANGIOTES CARODEMOS, "Relation of Salts and Gases of Milk to the Electrical Resistance and Solvent Action of Milk on Copper." HERBERT LEROY DAVIS, "Osmotic Pressures of Concentrated Solutions." HUGH BAYNARD HODGE, JR., "Viscosity Relationships in the System—Sulfuric Acid: Nitric Acid: Water." DONALD AUBREY HOLT, "Persistence and Sensitivity of Arc Spectral Lines." LEON E. JENKS, "Plasticity of Clay." RAYMOND ELLER KIRK, "A Contribution to the Chemistry of Hydrazine." LAWRENCE GANE KNOWLTON, "Some Experiments on Iron." LOUIS LEONARD LARSON, "Physico-Chemical Studies on Gelatin." JACK MISCALL, "Physico-Chemical Study of the Effects of the Gases Dissolved in Fresh Milk, Especially Carbon Dioxide, upon the Reaction in Milk during Processing." ROBERT LOGAN NUGENT, "Concentration Effects with Selective Membranes." LYTLE RAYMOND PARKS, "Turkey Red Dyeing." EARL WALTER PHELAN, "A Contribution to the Chemistry of Hydroxylamine." CHARLES HAMILTON SAYLOR, "Calcite and Aragonite." ROMULUS SEITZ VON HAZMBURG, "Equilibrium in Certain Binary Systems with One Volatile Component." CASPAR SHAPIRO, "Hydroquinolsulfonphthalein and Some of Its Derivatives. The Absorption Spectra of Hydroquinolphthalein and Hydroquinolsulfonphthalein." JOHN VETREES STARR, "Reflection Factors of White Paint." WESLEY GABRIEL VANNOY, "Induced Reactions." GEORGE PAUL VINCENT, "The Detergent Action of Soaps. II." CYRIL JAMES WATSON, "A Study of the Reactions Involved in the Determination of Minute Traces of Iodine and an Application to Some Feeding Experiments with Fish Meal."

**Fordham**

ALFRED LAZARESCO, "The Relation of Vitamin A Deficiency to Anemia." RUTH CLARKE SULLIVAN, "The Carbohydrates in the Cerebrospinal Fluid."

**George Washington**

WARD KUENTZEL, "Selective Catalytic Oxidation of Carbon Monoxide in the Presence of Hydrogen."

**Harvard**

STEPHEN FOSTER DARLING, "The Action of Bases on Nitrocyclopropanes." MALCOLM DALE, "A Study of the Dissociation of Barium Chloride in Water." ROBERT CABANISS GOODWIN, "The Conversion of Bromo Nitro Ketones into Oximido Esters." HAROLD SKINNER KING, "Attempts to Separate the Isotopes of Lead and Mercury." MILAN ALEXANDER LOGAN, "I. A Method for the Determination of Calcium in the Presence of Large Quantities of Magnesium and Phosphate. II. A Method for the Determination of Magnesium in the Presence of Large Quantities of Phosphate. III.

A Study of Calcium Excretion." BEVERIDGE JAMES MAIR, "I. Thermochemical Investigations of Aqueous Solutions. II. Compressibility."

### Illinois

TALBERT WARD ABBOTT, "Catalytic Reduction of Acetylene and Ethylene Compounds." JAMES AUGUSTUS ARVIN, "The Synthesis of Certain Cyclopentenyl and Certain Cyclopropyl Substituted Aliphatic Acids." ARTHUR GIDEON COLE, "The Proteins of Egg White. The Proteins in Egg White and Their Relationship to the Blood Proteins of the Domestic Fowl as Determined by the Precipitin Reaction." GERALD HAWLEY COLEMAN, "The Synthesis and Bacteriological Value of Compounds Related to Chaulmoogric Acid." CHARLES CURTIS COONS, "Thermal Transpiration and Thermal Dissociation in Iodine and Bromine Vapors." LETHA ALLISON DAVIES, "I. The Structure of Convolvulinolic and Jalapinolic Acids. II. The Preparation of Certain Dicyclohexylalkyl Acetic Acids." CHESTER GUSTAVE GAUERKE, "The Action of Grignard Reagents on Derivatives of Dibasic Acids." JAMES FRANKLIN HYDE, "I. Some Synthetic Homologs of Ephedrine. II. Study of the Structural Isomerism of Certain Diphenyl Derivatives." ROBERT THIES LESLIE, "Transference Numbers of Ions in Solid Sodium Chloride at High Temperatures." LAWRENCE FORSTALL MARTIN, "Syntheses of Phenyl Substituted Aliphatic Acids of High Molecular Weights." RAYMOND MERCHANT, "I. Syntheses in the Pyridine, $\beta$-Piperidine Series. II. A Synthesis of Proline." LAURENCE LARKIN QUILL, "Observations on the Rare Earths. Studies in Absorption Spectra." PAUL LAWRENCE SALZBERG, "The Stability of Hexa-Substituted Ethanes: Hexa-tert.-butylethynylethane." ARTHUR GALBRAITH SCROGGIE, "Studies on the Preparation, Properties and Structure of Silicoduodecitungstic Acid." ROY SOUKUP, "A Study of the Partial Oxidation of Methane and Ethane in the Presence of Catalysts." BEULAH DOROTHEA WESTERMAN, "The Availability of Disulfide Acids as Supplementing Agents in Diets Deficient in Cystine."

### Indiana

JOHN TILMAN BRUNDAGE, "The Isolation and Identification of Hemopoietic Substances Derived from Certain Tissues." ERROLL LIONEL FOX, "The Hydration of Magnesia as a Cause of Plasticity."

### Iowa

ADELAIDE PAULINE BARER, "A Critical and Experimental Study of Glycolysis." ARTHUR WILLIAM CAMPBELL, "The Addition of Nitrogen Trichloride to Unsaturated Aromatic Compounds." SYLVIA MARIE GOERGEN, "The Adsorption and Catalytic Properties of Stannous Oxide." HOYT CONLIN GRAHAM, "The Effect of Electrolytes and Hydrogen-Ion Concentration on the Sedimentation of Pleistocene Clays." CHARLES ROY HAUSER, "The Formation of Primary Amines from Grignard Reagents and Monochloroamine." LUCEA MARIAN HEJINIAN, "The Study of Growth in Infants from the Standpoint of Physical Measurements and Nitrogen Metabolism." ERNEST ELVIN MCCOLLOUGH, "Thermal Expansion of Binary Alloys of Aluminum." LLOYD MCKINLEY, "The Heats of Adsorption of Certain Organic Vapors on Charcoal at 25°." DEMPSIE B. MORRISON, "Biochemical Studies of Aluminum." JAMES WILLIAM MULL, "The Retention of Aluminum in the Animal Organism." EDWARD MUNTWYLER, "The Acid-Base Equilibrium of the Body. II. A Consideration of the Colorimetric Method of Estimating the Hydrogen-Ion Concentration of the Blood." VERNON MONROE STOWE, "Some Solubilities in Non-Aqueous Solvents." ALVAH LLOYD TAYLOR, "The Adsorption of the Vapors of Certain Alkyl Chlorides by Activated Charcoal." GARRETT WILLIAM THIESSEN, "The Effects of Substituents in the For-

mation and Reactions of Diphenyl Ethers. II." ROBERT GRAHAM TURNER, "Studies on Uric Acid: the Determination of a Previously Undetected Component of Blood and Its Relationship to Uric Acid and Thioneine."

**Iowa State College**

OLIVER WENDELL CHAPMAN, "The Properties of Starch with Relation to Time of Formation of Starch Gels." HYRUM EDWARD FLANDERS, "I. The Causes of Incomplete Graphitization Near the Surface When White Cast Iron Is Malleableized. II. The Production and Prevention of Embrittlements in Malleable Castings by Heat Treatments below the Critical Range." LEON C. HRECKET, "I. Some Aliphatic Local Anesthetics. II. The Physical Constants of Organo-Magnesium Halides." WILLIAM HARNEY JENNINGS, JR., "I. The Heat of Formation of Cementite as Electrolyzed from a Pure Iron Carbon Alloy of Eutectoid Structure and Composition. II. The Relation between pH and the Stoichiometrical Molality of the Hydrogen Ion in Mixed Electrolytes. III. A Proposed Ternary Diagram for the System Fe–C–Si in the Critical Range." AMY M. LEVESCONTE, "Biological Determination of Glucose." SITARAM D. SATWALEKAR, "Reactions of Liquid Hydrogen Sulfide on Metals and Oxides." FERDINAND SCHULZE, "Organo-Metallic Compounds of Group II." MILO J. STUTZMAN, "The Effect of Nickel upon the Stability of Iron Carbide and upon the Microscopic Structure of White Cast Iron Compositions." CLARENCE CLARK VERNON, "Physiological Action and Chemical Constitution. New Local Anesthetics." RALPH B. WAITE, "Reduction by Hydrogen."

**Johns Hopkins**

GEORGIAN ADAMS, "A Method for the Biological Assay of Cod-Liver Oil." WEAVER RINEHART CLAYTON, "Reactions of Thiodiglycol." LEWIS COVELL COPELAND, "The Heat of Dissociation of Molecular Hydrogen." WARRICK RIGELEY EDWARDS, JR., "A New Series of Cyclopentane Derivatives." RAYMOND MCGEARY HANN, "I. Schiff's Bases Derived from Chlorovanillin. II. Phenacyl, *p*-Chlorophenacyl and *p*-Bromophenacyl Esters of Some Higher Fatty Acids. III. Isomeric 2-Tolylimino-3-Tolyl-4-Phenyl-, *p*-Chlorophenyl- and *p*-Bromophenyl-$\Delta^{4,5}$-Thiazolines." ELLIS HAWORTH, "The Specific Heats of Some Derivatives of Benzene and the Thermal Energy of the Substituent Groups Therein." LEE ROY HERNDON, "The Decomposition of Organic Compounds at High Temperatures and Pressures." HARVEY THOMAS KENNEDY, "Critical Temperature Measurements on Carbon Dioxide in Small Capillaries." GEORGE HENRY LATHAM, "The Thickness of Adsorbed Vapor Films. II. The Adsorption of Polar Compounds on Plane Glass Surfaces." GEORGE ISRAEL LAVIN, "Reaction of Atomic Hydrogen and of Dissociated Water Vapor." ERNEST MELSON MARKS, "I. The Ethylation of Benzene. II. Some Derivatives of *s*-Triethylbenzene." JEREMIAH ALBERT PIERCE, "A Study of the Reaction between Nitric Oxide and Hydrogen Sulfide." JOSEPH JOHN SULLIVAN, "Catalytic Studies on Acetoacetic Ester." ROBERT NILES WASHBURNE, "Black Body Radiation and the Decomposition of Nitrogen Pentoxide in Molecular Beams." THOMAS LEIGH WILLIAMS, "Factors Affecting the Catalytic Behavior of Cobaltic Oxide—Study of Cobaltic Oxide as a Catalyst in Carbon Monoxide Oxidation." CHANNING WARD WILSON, "A Study of Gaseous Effusion at High Temperatures." EDITH WILSON, "The Decomposition of Nitrogen Pentoxide at Low Pressures."

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thanes, Ureas, and Thioureas." LEWIS GIBSON LONGSWORTH, "The Moving Boundary Method for Determining Transference Numbers."

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### Massachusetts Institute of Technology

FREDERICK WILDES ADAMS, "The Reactions of Lime and Water." KE CHUNG CHANG, "Rate of Interaction between Vapors and Liquids." MERRELL ROBERT FENSKE, "Studies of Methanol Catalysts." CHARLES KIDDELL LAWRENCE, "A Study of the Compressibility of Gaseous Ammonia." WILLIAM JOSEPH SWEENEY, "The Electrode Potential of Iron and Its Relation to Corrosion."

### Michigan

JOHN CHRISTIAN BAILAR, JR., "Studies in the Halogen Substituted Pinacols and the Possible Formation of Ketyl Radicals, $R_2 : C{\cdot}OMgI$." YING FU, "Studies in Adsorption. I. Adsorption from Aqueous Solutions by Silica. II. Specific Surface of Carbon and Silica from Heat of Wetting Data." KATHARINE MABON JARVIS, "A Study of Calcium Metabolism." WARREN LEE MCCABE, "Crystal Growth in Aqueous Solutions." CLIFFORD KANNE SLOAN, "An Interferometric Investigation of Adsorption by Pure Carbon from Non-Aqueous Binary Systems over the Entire Concentration Range." GENEVIEVE STEARNS, "Studies on the Intermediary Metabolism of Cystine." FRANK JOHN LEWIS VAN NATTA, "The Reduction of Substituted Benzils by the Binary System, Magnesium and Magnesium Iodide (or Bromide)." PHILENA ANNE YOUNG, "The Volumetric Determination of Vanadium and Chromium in Special Alloy Steels. Ceric Sulfate as a Volumetric Oxidizing Agent."

### Minnesota

RALPH FINNEY BEARD, "A Study of the Kinetics of the Stoichiometric Reaction in the Light of Recent Activity Rate Theories." RALPH EMMETT BREWER, "Colorimetric and Electrometric Measurements of Hydrogen-Ion Concentration in Acid Commercial Plating Baths." HELEN MARJORIE CRAWFORD, "The Reaction between Duroquinone and the Grignard Reagents." MILES AUGUSTINUS DAHLEN, "Some Derivatives of Diphenyl Ether." JOSEPH AVERY DUNN, "Factors Influencing Checking in Biscuits." HERBERT ARMIN PAGEL, "The Stability Ranges of Certain Rare Earth Oxides." ROE EUGENE REMINGTON, "Electrical Conductivity as a Measure of the Permeability of Cells of the Beet Root." GEORGE ARTHUR RICHARDSON, "Studies on the Chemical Nature of Casein and of Paracasein and the Colloid Chemistry of the Cheese Clotting Process." CARYL SLY, "Hexabromoazobenzene and Hexabromohydrobenzene." BEN EDMUND SORENSON, "Studies on the Reduction of Sulfonic Acids." LESLIE FIELD STONE, "Studies on Organic Depolarizers." LLOYD MASSENA THURSTON, "The Rôle of the Antiscorbutic Vitamin in the Nutrition of Calves." CHRISTIAN JOHN WERNLUND, "Studies on Organic Depolarizers." ROBERT BYRON WHITNEY, "A Study of the Intermediate Compounds in the Catalytic Decomposition of Halogenated Phenol Salts."

### Missouri

ELLA CHARLOTTE ROGERS, "Quantitative Determination of Vitamin B in Raw and Cooked Spinach and String Beans." CHARLES LESLIE SHREWSBURY, "A Study of the Dietary Constituents Essential for the Nutrition of the Chick."

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WILLIAM M. HARLOW, "Contributions to the Chemistry of the Plant Cell Walls."

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RALPH WALTON BOST, "Para-Cymylene-2,5-Diamine." SAMUEL CORNETTE COLLINS, "Ammonia Complexes of Lithium Chloride." WILLIAM MILFORD LOFTON, JR., "Emulsification of Tars and Asphalts." HOWELL GRADY PICKETT, "The Sulfur Factor in the Synthetic Methanol Reaction."

### Northwestern

RALPH HERBERT EDEE, "The Preparation of Unsymmetrical Aromatic-Aliphatic Arseno Compounds and Higher Arseno Compounds." RICHARD DANIEL GREENE, "Studies in the Reactivity of the Methylated Sugars. Action of Dilute Alkali on Tetramethylmannose." RALPH VINCENT MCGREW, "Arsenated Fatty Acids and a Study of Meyer's Reaction." FRANK WILLARD JOHNSON, "The Monoalkylation of Arylamines."

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### Pennsylvania

HAROLD EMORY FENIMORE, "The Electrochemical Oxidation of Benzene. Preparation of Quinone." JOHN MCARTHUR HARRIS, JR., "The Activity Coefficient of Alkali Hydroxides in Alkali Chloride Solutions." KENNETH BRADDOCK ROGERS, "The Action of Air-Carbon Tetrachloride Vapor Mixtures on Certain Natural and Artificial Sulfides and on Selenides and a Telluride."

### Pittsburgh

HAROLD PAUL AVERILL, "The Relation between the Chemical Constitution and Physical Properties of the Triglycerides." FREDERICK RHINEHART BALCAR, "The Adsorption and Solution Phenomena Encountered in Precipitations." CHI FANG LAI, "The Preparation and Study of Beryllium Glasses." LEWIS EARL MILLER, "The Catalytic Oxidation of Carbon Monoxide by Titania and Mixtures of Titania with Various Metallic Oxides." WALLACE SWANZEY PECK, "The Free Energy of the Sulfonation of Benzene." JAMES NORMAN ROCHE, "The Relation between the Chemical Structure and Physical Properties of Triglycerides." HUBERT EDMUND WOODWARD, "A Study of Conditions Affecting the Electrolytic Preparation of Sodium Amalgam."

### Princeton

HUBERT NEWCOMBE ALYEA, "The Mechanism of Inhibition of the Sodium Sulfite Oxidation by Alcohols (a Contribution to the Chain Reaction Theory of Inhibition)." EDWARD WILLIAM ENGEL, "The Vapor Pressures of Binary Liquids." ELMER ELLSWORTH FLECK, "The Action of Thiocyanogen upon *o,n*-Disubstituted Hydroxylamines and Primary Amines." STANLEY OWEN MORGAN, "The Polarization of Binary Liquid Mixtures." WENDELL SHERMAN NIEDERHAUSER, "Polarization and Hysteresis in Standard Cells." ALBERT STARNES RICHARDSON, "Nature of the Combination of Water and Electrolyte with Soap." VICTOR CLYDE ROGERS, "The Hexaphenylethane Alkyl Sulfide Addition Products." SYDNEY LONGSTRETH WRIGHT, JR., "Studies in Ebullioscopy."

### Radcliffe

OLIVE WATKINS, "The Occurrence of Lactose in Urine."

### Rensselaer

FREDERICK EARL WAGNER, "An Investigation of the Chemical Changes Occurring in the Roasting of Coffee."

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G. E. CUNNINGHAM, "Absorption of Ions and the Physical Character of Precipitates."

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CLARENCE J. WEBER, "Studies on Carbohydrate Metabolism."

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CLAYTON CREE SPENCER, "The Study of the Acetolysis of Cotton Cellulose."

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RAYMOND DEAN COOL, "The Kinetics of Polymorphic Transitions of Solids." HENRY EDWIN SHIVER, "The Equilibrium between Creatine and Creatinine."

### Washington

JAMES RICHARD LORAH, "A Basic Phosphate of Calcium and of Strontium and the System (Acid Range) $SrO–P_2O_5–H_2O$ and $BaO–P_2O_5–H_2O$."

### Wisconsin

CHARLES SPURGEON BLACK, "A Chemical Study of Lake Muds." AUBREY ERNEST BRODERICK, "Some Relations of Structure, Reactivity, and Affinity in Catalytic Organic Reactions." BERTIE LEE BROWNING, "A Study of the Hydrolysis of Calcium and Magnesium Carbonates." SZE YEE CHEN, "A Study of *Illicium Religiosum* Mang Tsao." JOHN O'NEILL CLOSS, "The Use of Simple Metallic Electrodes in the Potentiometric Titration of Acids and Bases." WALLACE PARKER ELMSLIE, "Calcium and Magnesium Relations in Animal Metabolism." HARRY LEONARD FEVOLD, "A Study of the Separation of Crystalloids." THERON GUTMANN FINZEL, "A Study of the Properties of Pyrophoric Iron." PERRY ALBERT FOOTE, "The Action of Nitrosyl Chloride on Hydrocarbons of the Methane Series." SIDNEY JAMES FRENCH, "Gas-Metal Electrodes." AUGUST GEORGE FRUEHAN, "The Preparation of Seleno Compounds of Tungsten and Molybdenum." ROY CLAIR JUDD, "I. Flocculation Studies with Ferric Oxide Hydrosols. II. A Thermostat for Low Temperatures. III. The Velocity and Crystallization of Undercooled Water." FREDERICK WILLIAM LAIRD, "The Effect of Electrolytes on the Shift in the Temperature of Maximum Density of Water from the Standpoint of the Lyotropic Series." DONALD WILLIAM MACCORQUODALE, "The Synthesis of Some Alkyl Xanthines." MARION BROOKS MATLACK, "The Chemistry of the Agrumens with Special Reference to that of Sweet Orange Peel." PAUL E. MILLINGTON, "The Selective Activation of Certain Metallic Oxides for the Dehydration and Dehydrogenation of Alcohols." JAMES BURTON NICHOLS, "Centrifugal Methods for Determining the Size and the Distribution of Size of Suspended Particles." HELMUTH H. SCHRENK, "I. The Reaction of Selenious Acid with Inorganic Oxides. II. The Effect of the State of Oxidation on the Toxicity of an Element." FRANCIS HENRY LASKEY TAYLOR, "A New System of Micro-Analysis and a Study of the Colloidal Systems Present in Natural Waters." JAMES RUSSELL THAYER, "The Preparation of New Local Anesthetics Containing a Piperidine Nucleus." PAUL EDWIN WESTON, "I. Catalysis with Copper in the Ullman Reaction. II. A Study of the Reactions of Unsaturated Alcohols and Aldehydes over Metallic Oxides as Catalysts." LAWRENCE CLIFFORD WHEETING, "A Study of Methods for the Determination of the Available Potassium of Soils."

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JAMES BLISS AUSTIN, "The Emission Spectra of Some Aromatic Hydrocarbons." MALCOLM KEE BUCKLEY, "The Solubility Relations in Three-Component Systems in Water, the Lower Alcohols and Some Hydrocarbons." YUOH FONG CHI, "A Method for Synthesizing Heterocyclic Compounds Containing Condensed Pyrimidine Rings." ANNA JOSEPHINE EISENMAN, "The Carbon Dioxide Absorption Curve of Human Blood." CLINTON SHEELY GROVE, "The Solubility of Calcium Hydroxide in Aqueous Salt Solutions." THOMAS GARDNER HAWLEY, JR., "The Isoelectric Point of Silk Fibroin." WALDERSEE BRAZIER HENDREY, "The Electrolytic Separation of the Amino Acids, Arginine and Alanine." GUIDO EDWARD HILBERT, "Diphenyl Sulfide Phenols and

Their Germicidal Value." MARION CAROLINE PFUND, "The Preparation and Chemical Properties of Iodoisatin." THEODORE HAROLD RIDER, "Syntheses of Glycidol and Its Application to the Preparation of Certain Nitrogen Bases." ELLIOTT JOHN ROBERTS, "The Antimony-Antimony Trioxide Electrode and Its Use as a Measure of Acidity." JOHN FRANK SCHAIRER, "The Quaternary System: $Na_2SO_4$–NaCl–NaF–$H_2O$." RODNEY PERKINS SMITH, "The Boiling Point Elevation of Solutions." MEYER SOLOMON, "The Mutual Solubility Relations of Some Aromatic Compounds." HAROLD MORTON SPURLIN, "Surface Films of Naphthalene Compounds."

## ENGINEERING

### Harvard

HERMAN GLENN BAITY, "Studies of Sewage Sludge."

### Massachusetts Institute of Technology

DANIEL PADDOCK BARNARD, 4TH, "Effect of Oiliness on Journal Lubrication."

### Michigan

CLAUDE LESTER CLARK, "The Evaluation of the Stability of Metals at Elevated Temperatures from Expansion and Short-Time Tensile Test Data." ALBERT BROADUS NEWMAN, "A Modified Method for the Determination of the Heat Capacity of Powdered Solids; Application to Powdered Crystalline Aluminum Oxide; Thermodynamic Deductions Concerning Crystalline Aluminum Oxide." EVERETT PERCY PARTRIDGE, "Laboratory Studies on the Formation of Calcium Sulfate Boiler Scale." WALTER JOSEPH PODBIELNIAK, "Vaporization of Complex Mixtures." ALFRED MCLAREN WHITE, "The Thermodynamics of Non-Isothermal Systems."

### Ohio State

ARTHUR MARSHALL BRANT, "Deadburned Lime." KAI-CHING LU, "The Glass Tank Refractories and Their Chemical Relationship with the Molten Class."

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FREDERICK YOUNG HERRON, "The Origin and Production of Fusel Oil."

## METALLURGY

### Columbia

AARON B. BAGDASARIAN, "Reduction of Metallic Chlorides by Hydrogen." WE WANG LOO, "Reduction of Roasted Cassiterite Concentrates." CHARLES LETNAM MANTELL, "Physico-Chemical Studies in Tin Metallurgy."

### Harvard

CHIH HUNG CHOU, "The Crystallization of Iron-Carbon Alloys—with Special Reference to the Widmanstättian Structure."

### Massachusetts Institute of Technology

CONSTANTINE STEPHENS STEPHANO, "The Extraction of Tin from Bolivian Concentrates by Methods Other than Fusion."

### Ohio State

ARTHUR ELDRIDGE FOCKE, "Some Factors Influencing the Quality of Tungsten Incandescent Lamp Filaments."

### Pittsburgh

HIMANSU KUMAR MITRA, "The Prevention of Disintegration of Blast Furnace Linings."

### Rensselaer

GEORGE PARMENTER DE FOREST, "An Investigation of Some Physical Properties of Cast Iron Alloyed with Nickel, Chromium, and Manganese." PETER R. G. KOSTING, "An Investigation of Some Physical Properties of the Nickel–Iron–Copper System."

### Wisconsin

IRA NATHAN GOFF, "The Viscosity of Binary Combinations of Iron Blast Furnace Slag Minerals." CLARENCE HERMAN LORIG, "The Electrical Conductivity of Binary Mixtures of Iron Blast Furnace Slag Minerals." LEO SCHAPIRO, "The Iron–Carbon–Chromium–Nickel System."

### Yale

ALBERT JOHN PHILLIPS, "Twinning in Relation to the Plastic Deformation of Metals."

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## PHYSIOLOGY

### Chicago

GEORGE FRANCIS CARTLAND, "Studies in the Organic Precursors of Hemoglobin." ONIS HARRISON HORRALL, "Toxicity of Bile." LEMUEL CLYDE MCGEE, "Biological Activity of Testicular Extracts." LYDIA JANE ROBERTS, "Nutrition Work with Children." ELLEN STEWART, "Alimentary Rate in the Vitamin Deficiency Diseases." JOSEPH ADOLPH TUTA, "Studies on the Oxidation-Reduction Potential of Blood." RUSSELL AMOS WAUD, "Sudden Transitory Reduction in the Viscosity of the Blood as a Cause of the Fall in Blood Pressure in Shock." HAROLD FISHER PIERCE, "Nitrocellulose Membranes of Graded Permeability."

### Iowa

FREDERICK FRANCIS YONKMAN, "The Acid Intoxication of Adrenal Insufficiency in Dogs."

### Iowa State College

JAMES BOYD ALLISON, JR., "Studies on the Toxicity of Hydrogen Cyanide." FISK GERHARDT, "Physiological and Chemical Studies upon the Milkweed (*Asclepias syriaca*, L.)." EDWARD GUERRANT KELLY, "Toxicity of Hydrogen Cyanide Gas on Animal Life."

### Minnesota

WILLIAM EARL PETERSEN, "A Study of Milk Fat Synthesis and Secretion."

**Northwestern**

LATHAN AUGUSTUS CRANDALL, "Contributions to the Pharmacology of the Nitrites."

**Ohio State**

EDWARD WALDO EMERSON SCHEAR, "The Content of Sugar in the Blood of *Mus Norwegicus Albinus* When Subjected to Low Temperature."

**Yale**

MARTHA KOEHNE, "The Utilization of Fatty Oils Given Parenterally." HELEN TRACY PARSONS, "Physiological Effects of a Dietary Rich in Protein during Pregnancy and Lactation in Rats after Removal of One Kidney." WILLIAM BRANDT ROSE, "Vitamin B in Relation to Blood Changes, Gastric Motility, and Infection."

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(*Continued from page 1447*)

fourths full of water. The size of the flask and the three necks are merely for convenience. Through each small neck of the flask a copper wire, inside a glass tube, is led to the heating coil. As the coil will have to be renewed (about once or twice a year depending on extent of use) it is best to solder leads to the ends of the copper wire, and then the coil can be easily connected. By using a two-hole stopper in each small neck, tubes for filling and draining the flask can be provided. A one-hole rubber stopper, through which passes a short piece of glass tubing, is placed in the large neck of the flask. This piece of glass tubing is connected to the bath pan by means of a piece of rubber tubing. It may be necessary to renew the rubber tubing from time to time.

This apparatus can be used to generate steam for a steam distillation by disconnecting the rubber tube and connecting the flask directly to the vessel containing the substance to be steam distilled.

Below is given a list of material used in constructing the steam-bath.

1 Straw ring support (or cork)
1 Three-neck three-liter Pyrex flask
1 Steam-bath pan
5 Ft. glass tubing (Pyrex) 5 mm. outside
1/2 Ft. glass tubing (Pyrex) 1 cm. outside
2 Two-hole rubber stoppers No. 3
1 One-hole rubber stopper No. 10
1 Pinch clamp
1 Small roll tape
1 Short piece rubber tubing
2 Ft. copper wire No. 12
6 Ft. resistance wire[2] (for 110 volts).

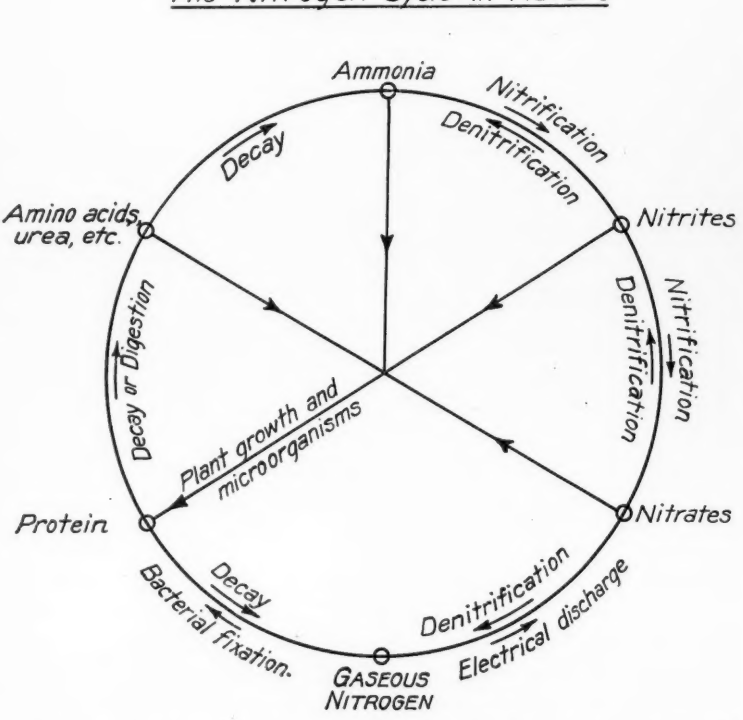
[2] The resistance wire used is: Chromel A, Size 24, 1.53 ohms per ft. Made by Hoskins Mfg. Co., 4445 Lawton Ave., Detroit, Mich.

# The Chemistry Student

## REVERSING THE NITROGEN DEBIT

OTTO REINMUTH, ASSOCIATE EDITOR

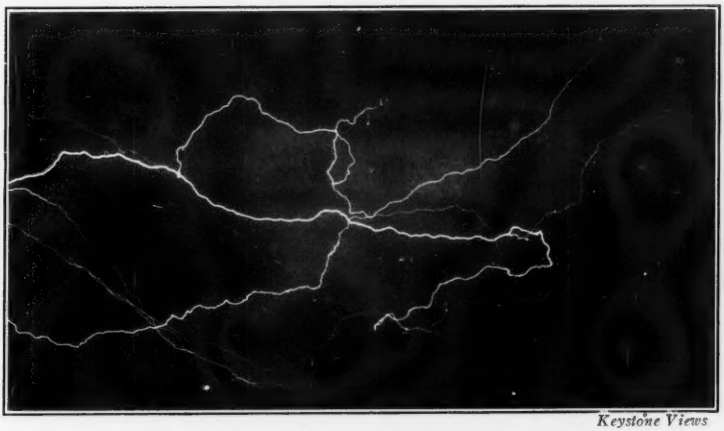
Nature is a vast, self-compensating mechanism, of intricately correlated parts—a combination of delicate, self-adjusting equilibria. A familiar example of this quality of self-adjustment is to be found in the cycle whereby water evaporates from the leaves of plants, the surfaces of rivers and




oceans, and countless other sources, only to precipitate again as rain and repeat the process, thus incidentally making possible the existence of plant life, on which all other life depends for existence. The carbon dioxide cycle is no less impressive. Carbon dioxide, drawn from the air,

is the chief food of plants, which in turn feed animals. Through the processes of digestion and respiration the gas is again released to the air to become once more potential food for plants.

The nitrogen cycle is more complicated than either of these—in fact we may say that there are a number of interlocking cycles of nitrogen. Of the two which are most important to us, the first involves nitrogen in the combined state only, and the second consists in the transfer of nitrogen from the combined to the free state and back again. The cycle of combined nitrogen is comparable to the carbon dioxide cycle. We can start with nitrates, which are taken up by plants and converted into proteins. These plant proteins may decompose and return to the soil through the death and decay of the plant or they may serve as food for animals. In the

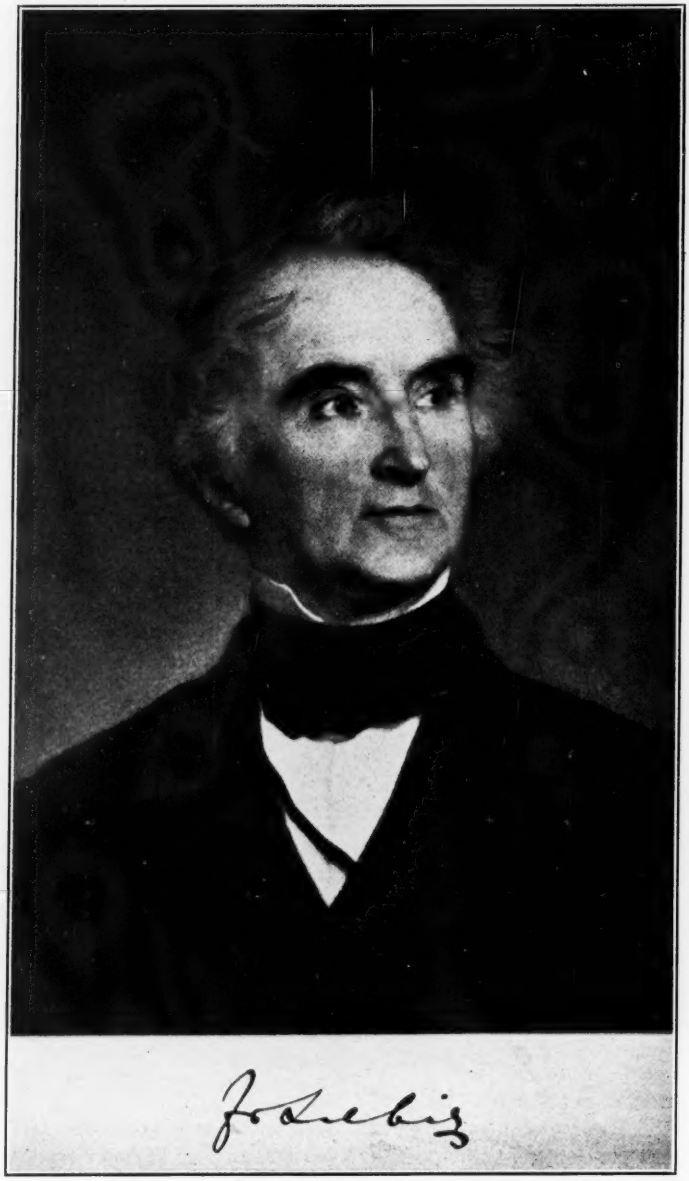


*Keystone Views*

ONE OF NATURE'S NITROGEN FIXATION PROCESSES

latter event they are partially converted into animal proteins and partially decomposed and excreted as urea, amino acids, etc. In either case the eventual decay of protein, plant or animal, and of animal excreta leads chiefly to ammonia. Ammonia compounds are oxidized by soil bacteria to nitrites and finally to nitrates and the cycle is completed. There are short cuts across this cycle. For instance, while plants depend chiefly upon nitrates for their nitrogen, experiments indicate that they can also make use of ammonia compounds and nitrites.

But there are also leakages in the cycle. The two great reservoirs into which lost nitrogen escapes are the sea and the air. Under certain unfavorable conditions, decomposition of plant or animal matter results in the release of free nitrogen into the atmosphere. Some soluble nitrogen compounds are also lost from the soil by being dissolved and washed into




Justus von Liebig, sometimes called the father of agricultural chemistry, who prophesied that, unless some way were found to prevent or replace nitrogen wastage, the world would eventually starve for lack of nitrogen.

streams and rivers and so carried to the sea. Under natural conditions these losses are small, and there are compensating gains. Certain bacteria are able to capture and fix the free nitrogen of the air, thus making it available for plants. One important class of nitrogen-fixing bacteria works in "symbiosis" or partnership with a group of plants which are known as the legumes. The legumes include peas, beans, clovers, alfalfa, and other plants. Small amounts of free nitrogen are also fixed by the electrical discharges of thunder storms.

The leakages, which are naturally so small as to be balanced by corresponding gains, are greatly increased by man's operations. Much of the produce of the land is carried to the great cities, and the waste products which would restore the fertility of the land are lost by being discharged into the rivers and oceans. Poor farming practices which allow lands to lie bare without cover crops to catch and hold water-soluble nitrogen compounds result in further tribute to the sea. The burning of straw and other plant refuse releases free nitrogen to the air. Under these conditions agriculture becomes a mining operation in which nitrogen is rapidly exhausted and scattered beyond possibility of reclamation. Just such practices have resulted in the ruin and abandonment of many farms in certain sections of our own country.

What is the remedy? Obviously, the first thing to do is to try to minimize the leaks. Better farming practices can eliminate some of them. Bacterial nitrogen fixation can be encouraged by the growth of legumes, but only to a certain extent. Our slaughter houses and various of our manufacturing industries can return certain of their wastes to the soil. But what of that ever-increasing tribute to the all-absorbing sea?

Liebig asserted in his day that the sewers of Rome had absorbed all the well-being of the Roman peasant. Victor Hugo wrote that France was being exhausted through the mouths of her rivers.

> Fleets of vessels are despatched, at great expense, to collect the dung of petrels and penguins at the South Pole,[1] and the incalculable elements of opulence which we have on hand, we send to the sea. All the human and animal manure which the world wastes, restored to the land instead of being cast into the water, would suffice to nourish the world.
>
> Those heaps of filth at the gate-posts, those tumbrils of mud which jolt through the street by night, those terrible casks of the street department, those fetid drippings of subterranean mire, which the pavements hide from you—do you know what they are? They are the meadow in flower, the green grass, wild thyme, thyme and sage, they are game, they are cattle, they are the satisfied bellows of great oxen in the evening, they are perfumed hay, they are golden wheat, they are the bread on your table, they are the warm blood in your veins, they are health, they are joy, they are life. This is

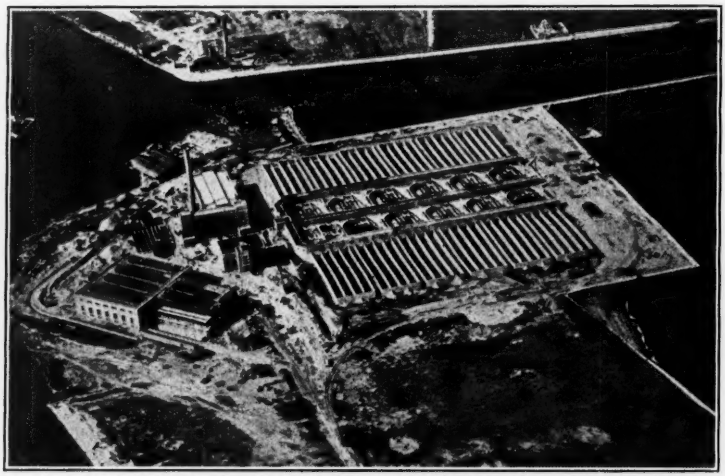
[1] Perhaps Hugo purposely exaggerated here. At any rate this geographical localization of guano deposits is not to be taken literally.

the will of that mysterious creation which is transformation on earth and transfiguration in heaven.

Restore this to the great crucible; your abundance will flow forth from it. The nutrition of the plains furnishes the nourishment of men.

You have it in your power to lose this wealth, and to consider me ridiculous to boot. This will form the masterpiece of your ignorance.

The remedy which the great French author suggested was simple, but it had its drawbacks. With a fine disregard for engineering difficulties, the interests of sanitation, and the public nuisance involved, he advocated that sewage be piped back to the land rather than into the waterways. As a matter of fact a number of experimental sewage farms have been



*Aerial Photographic Service Corporation of Chicago, through C. E. McCreedy, Inc., Milwaukee. Reproduced by courtesy of Industrial and Engineering Chemistry*

MILWAUKEE SEWAGE DISPOSAL PLANT

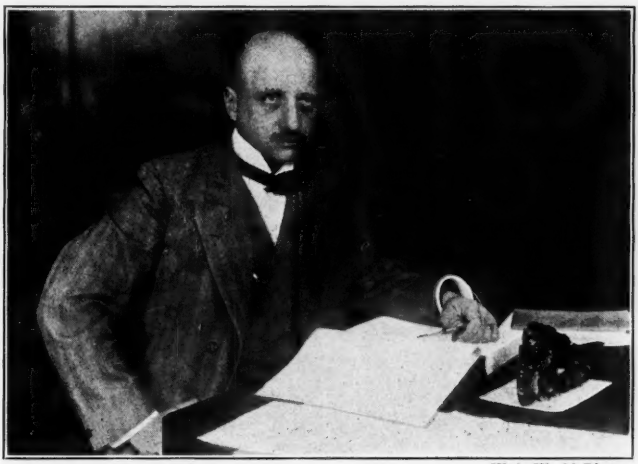
established in Great Britain, France, and Germany, but have failed to show a profit on operations, to say nothing of paying any interest on the investment involved. Whatever might be the success of such ventures upon an experimental scale, it is obviously both undesirable and impossible that such methods of sewage disposal be universally employed.

The idea of waste reclamation has never been totally abandoned, although in the case of sewage it has been developed secondarily, as a means of reducing the cost of necessary sanitation operations through the sale of by-products. Garbage can be reduced with actual profit, it appears, if the most advanced scientific methods are employed, but the profit depends on the recovery of fats and the production of a certain amount of

tankage suitable for animal feeding, rather than upon complete conversion to fertilizer.

*Courtesy of Industrial and Engineering Chemistry*

TANKS IN WHICH GARBAGE IS DIGESTED BY MEANS OF STEAM AND FROM WHICH IT EMERGES AS PRACTICALLY DRY TANKAGE



*Wide World Photos*

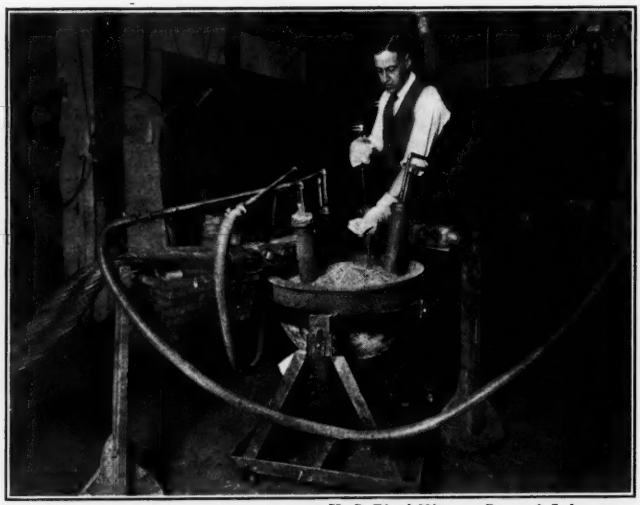
DR. FRITZ HABER, DIRECTOR OF THE KAISER WILHELM INSTITUTE AT BERLIN, WINNER OF THE 1918 NOBEL PRIZE FOR CHEMISTRY, AND INVENTOR OF THE PROCESS FOR SYNTHESIZING AMMONIA

With either garbage or sewage, but particularly with sewage, the two greatest problems involved are the concentration of waste by removal

of the great excess of water and the conversion of the material into a less unpleasant form. Both of these problems have been attacked with a certain degree of success and several large cities are now reclaiming a great deal of their sewage and garbage by chemical and bacteriological processes.[2]

Yet it must be evident that even though sewage and garbage reduction processes were adopted by all large cities, the wastage would still be enormous. Much soluble nitrogen is lost in the waters which must be discarded. The evil day of nitrogen starvation which Liebig and other chemists foretold would be deferred but not prevented.

So far we have spoken chiefly of the toll exacted by the sea, but the air



*U. S. Fixed Nitrogen Research Laboratory*

FUSION-POT USED IN THE PREPARATION OF AMMONIA CATALYSTS

has also swallowed up fortunes in nitrogen. No war since the invention of gunpowder has failed to release vast quantities of the precious element in its inactive, gaseous form. Every blast of the peace-time explosives so indispensable in construction and mining operations is another draft on the world's supply of fixed nitrogen.

Fortunately, we have not had to solve our problem all at once. The guano accumulations of South American islands and the sodium nitrate deposits of Chile have acted as emergency funds upon which we could draw.

[2] See "Water Supply and Sewerage during the Past Fifty Years," Robert Spurr Weston, *Ind. Eng. Chem.*, **18**, 899–901 (September, 1926) and "Progress in Garbage Reduction," Harrison E. Howe, *Ind. Eng. Chem.*, **19**, 608–13 (May, 1927). These articles are short and expressed in clear and, for the most part, non-technical language.

But it has been evident that these could not last forever. So far as nitrogen was concerned the world had been living like a man who had calmly quit work and was drawing a little more out of his savings account to pay the bills on the first of each month. By-product ammonia from coking operations has helped, but here again we are drawing upon a source of supply which cannot be considered inexhaustible.

After all, the only adequate solution had to be sought in one of the two great reservoirs of escaped nitrogen—the sea or the air. While there are nitrates in sea water, they are so diluted and so contaminated with undesirable compounds that they cannot be reclaimed economically. But the sea like the land has its *flora* and *fauna*. The combined nitrogen

*U. S. Fixed Nitrogen Research Laboratory*

TESTING AMMONIA CATALYSTS

cycle which we have mentioned operates in the oceans as upon the earth. Some nitrogen can be withdrawn from the sea in the form of fish. This source of supply is however strictly limited by economical considerations. It does not pay to fish for nitrogen alone.[3] Only as a by-product of canning operations, oil-extraction, or animal feed manufacture, can the nitrogen of the sea be reclaimed economically. We have been forced to seek our future food supplies in the air.

[3] Some of our fishing is done for us by the South American guano birds which we have previously mentioned. They furnish us with a steady but very small supply of nitrogen reclaimed from the sea. For a description of the guano industry see the illustrated article, "Queer Birds Worth Millions," by Homer Croy in the November, **1928.** *Popular Science Monthly*, pp. 52–53.

At first man imitated one of the minor processes of Nature—the oxidation of nitrogen by means of electrical discharges. For this process enormous supplies of energy to develop electric current were necessary. It cost too much to obtain that energy by burning coal. Water power seemed to offer a possible solution, but after all it proved only a partial solution. Only where water power was exceptionally abundant and in comparatively little demand for other manufacturing operations, did it pay to convert "white coal" into fixed nitrogen.

Later a different electrical process—the cyanamid process—was developed. This method was less wasteful of power than the original one but even yet it did not give synthetic nitrogen compounds an "even break" with natural products, economically speaking.

These processes represented great strides forward. They guaranteed that no country need be shut off from nitrogen through war or other causes and that the world in general could avert eventual nitrogen starvation, even though it might have to pay a high cost in so doing. They were safeguards against an evil day—and that was a great deal. But what was really wanted was a process which would make it more profitable to produce combined nitrogen than to gradually exhaust our reserve funds.

It was here that the newer chemistry—the chemistry of catalysis—achieved a brilliant triumph in the Haber process. The Haber process, which consists in catalytically combining nitrogen and hydrogen to form ammonia, does not take its cue from nature. So far as we know this reaction takes place nowhere save in the laboratory and factory. Here, as elsewhere (in aviation for instance), science has found that it can do better by creating its own methods, based upon natural laws, of course, but not imitative of anything which can be observed in Nature.

The Haber process is complemented by another application of catalysis—the oxidation of ammonia to form nitric acid. With the aid of these two operations we are able to draw, from the inexhaustible but hitherto tightly locked storehouse of the atmosphere, nitrogen for either agricultural or industrial purposes and at a cost no greater than that involved in our previous wasteful methods. Man has succeeded in restoring an equilibrium which he had ignorantly and carelessly destroyed.

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**Large New German Coke Plant.** A large coke plant is being completed near Gelsenkirchen, Germany, for the United Steel Works. There will be a battery of forty-two coke ovens, each with a capacity of 30 tons daily. A further one hundred and twenty-six ovens are to be erected, when the daily output will be 5200 tons of coke, sixty tons of benzole, eighty tons of ammonia, and two hundred and forty tons of tar.—*Chem. Age*, **19**, 284 (Sept. 29, 1928).

# THE STRUCTURE OF MATTER. III. SOME MISCELLANEOUS APPLICATIONS

OTTO REINMUTH, ASSOCIATE EDITOR

Last month[1] we left the periodic table apparently headed for a snag, yet not without some assurance that a catastrophe could be averted. This was not, as some readers may have suspected, an attempt to imitate the methods of the serial story writer and inject an element of suspense. Nor, in deferring a resumption of our discussion of the table, are we actuated by a desire to prolong such suspense as may exist. The impatient are hereby given full leave to resort to the library and find out the answer in advance, if they have not already done so.

In the meantime it appears desirable to turn aside from this theme to consider a few of the elements, compounds, and reactions which are customarily discussed in elementary chemistry classes at about this season of the year, and to examine them in the light of such theory as we have already built up.

## Nitrogen and Phosphorus

We have already noted the fact that the periodic table was the outcome of the recognition of chemical similarities between elements. Let us reverse the historical process and compare for a moment two elements which, because of their juxtaposition in the table, should display similarities—nitrogen and phosphorus.

At once we are struck by the very apparent dissimilarity between the two elements themselves. Nitrogen in the elementary state is a gas notorious for its chemical inactivity. It does not combine with oxygen except under the influence of very drastic treatment—in the electric arc. It combines with hydrogen only at high temperatures and pressures in the presence of a catalyst. Chlorine, an extremely active element, does not affect it. Solid white phosphorus, on the other hand, oxidizes spontaneously upon exposure to moist air. When warmed with KOH solution it readily forms $PH_3$. When melted, it combines directly with chlorine. Why is nitrogen so inactive while phosphorus is so active?

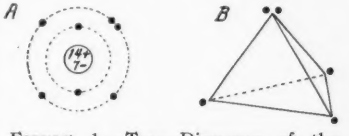



FIGURE 1.—Two Diagrams of the Nitrogen Atom.

As a matter of fact the inactivity of nitrogen is more apparent than real. In its compounds nitrogen displays the activity which we would expect from a consideration of its structure. It is only in the molecular form that nitrogen is sluggish and inert. In the preceding article of this

[1] "The Structure of Matter. II," THIS JOURNAL, **5**, 1312–20 (Oct., 1928).

series[1] we sketched the specifications for the nitrogen atom as in Figure 1A. In order to arrive at an explanation of the behavior of the nitrogen molecule, let us outline the nitrogen atom according to the tetrahedral scheme which we discussed in September[2] (see Figure 1B). A glance at either diagram reveals the fact that the atom can complete its stable octet by matching three of its electrons with three electrons from another atom, or other atoms, and sharing three electron pairs (with it or them). Vapor density measurements show that gaseous nitrogen is properly represented by the formula, $N_2$.[3] Hence, the diagram set forth in Figure 2 may be considered as a reasonable representation of the nitrogen molecule. Here the observer will note that, not only has each atom completed its stable octet, but that the molecule as a whole has an exceptionally symmetrical conformation. Like the ancient Greek phalanx it presents a solid front to the world. There is no point of penetration; only by smashing the formation can an entrance be effected.

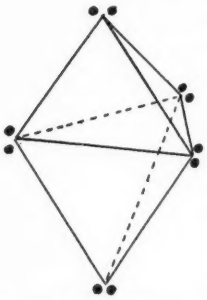


FIGURE 2.—The Nitrogen Molecule.

But, we may ask, does not the same thing hold true for phosphorus? Apparently not. Vapor density measurements show that, in the gaseous state, phosphorus has the formula $P_4$. In the solid state the phosphorus molecule is even larger, probably indeterminate (*i. e.*, crystalline).[4] It is difficult to offer any satisfying explanation why this should be so. Professor G. N. Lewis has advanced the hypothesis that "the ability to form multiple bonds is almost entirely, if not entirely, confined to elements of the first group of eight, and especially to carbon, nitrogen, and oxygen."[5] This hypothesis is not, of course, an explanation; it is merely a more generalized statement of the particular fact before us. Once accepted, however, it helps to account for a number of dissimilarities, not only between nitrogen and phosphorus, but between carbon and silicon and between oxygen and sulfur as well.

[2] "The Structure of Matter. I," THIS JOURNAL, **5,** 1152–63 (Sept., 1928).

[3] The vapor density of a gas may be ascertained either by determining the mass of a known volume or by determining the volume of a known mass. In either case the molecular weight of the gas can be calculated by applying the principle of Avogadro. Unless the vapor investigated follows the gas laws very closely the molecular weight so obtained will be only approximate, but it will enable us to choose without hesitation between the simple formula weight and some multiple thereof.

[4] For a discussion of the crystal as an indeterminate molecule, see "The Structure of Matter. IV. The Structures of Crystals," Maurice L. Huggins, THIS JOURNAL, **4,** 73–83 (Jan., 1927).

[5] "Valence and the Structure of Atoms and Molecules," G. N. Lewis, The Chemical Catalog Co., **1923,** p. 94.

Let us pause for a moment to consider just what this hypothesis implies in relation to our immediate problem. It will be recalled that we have already defined the non-polar (or partially polar) chemical bond as a pair of valence electrons shared between two atoms.[2] Then, if an element is incapable of forming multiple bonds one of its atoms can share only one pair of valence electrons with any other one atom. If it is considered that the electron pairs are distributed about the atomic nucleus as though situated at the corners of a regular tetrahedron, it follows that two atoms joined by a single bond must be represented by two tetrahedra possessing one common corner (Figure 3A). Two atoms joined by a double bond must be represented by two tetrahedra with a common edge (Figure 3B), and two atoms joined by a triple bond by two tetrahedra with a common plane (Figure 3C).

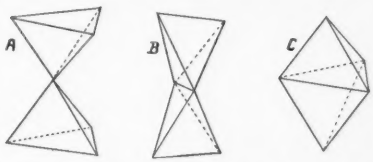



FIGURE 3.—*A*, the single bond; *B*, the double bond; *C*, the triple bond.

Returning to the question which confronts us, it is evident that if phosphorus is incapable of forming multiple bonds it cannot achieve any such stable conformation as that which we sketched to account for the inactivity of molecular nitrogen. Unfortunately, the writer's draftsmanship is not equal to the task of portraying the $P_4$ molecule in accordance with the tetrahedral idea. Resorting to the older system of representing structural formulas it is possible to diagram the molecule somewhat as follows:

where each line represents a chemical bond or shared electron pair. Since stability is closely allied to inactivity we should expect that, of two unlike molecules, the more stable would be the less reactive. This is true of the molecules $N_2$ and $P_4$.

Having partially explained the great difference between elementary nitrogen and elementary phosphorus let us compare a few of their compounds. It is not difficult to select a system of analogs or pairs of compounds which differ in composition only by reason of the fact that where nitrogen occurs in one member of the pair, phosphorus appears in the other. Some of these are listed in Table 1.

These analogous pairs are alike in structure and similar in chemical properties, but display such differences in physical characteristics and degree of reactivity as might reasonably be expected from the compounds of two elements of different nuclear charge.

The student who cares to pursue the comparison farther will find that some nitrogen compounds possess no phosphorus analogs and vice versa. The lower oxides of nitrogen furnish an outstanding example. Here again

TABLE I

SOME NITROGEN-PHOSPHORUS ANALOGS

| | | | |
|---|---|---|---|
| Ammonia | $NH_3$ | $PH_3$ | Phosphine |
| Nitrogen trichloride | $NCl_3$ | $PCl_3$ | Phosphorus trichloride |
| Ammonium chloride | $NH_4Cl$ | $PH_4Cl$ | Phosphonium chloride |
| Nitric acid | $HNO_3$ | $HPO_3$ | Metaphosphoric acid |
| Nitrogen peroxide | $N_2O_4$ | $P_2O_4$ | Phosphorus tetroxide |
| Nitrogen pentoxide | $N_2O_5$ | $P_2O_5$ | Phosphorus pentoxide |

the apparent disinclination of phosphorus to either form multiple bonds or to exist in an unsaturated state[6] accounts for the difference in the behavior of the two elements, although this characteristic itself remains unexplained.

## More about Valence

Nitrogen and phosphorus are invariably described as possessing chief valences of three and five and a review of their compounds seems to support the statement. At first glance this is what would be expected upon the basis of the fact that the atoms of these elements have five electrons in the valence shell. We might be inclined to say that a stable octet could be attained either by discarding five electrons to strip off the outer shell or by borrowing three electrons from another atom or atoms. There is also the possibility of electron-sharing. Since we know of no such ions as $N^{3-}$, $P^{3-}$, $N^{5+}$, or $P^{5+}$ (which would result from the complete gain of three or loss of five electrons) let us confine our attention to the possibilities of electron sharing.

There is of course no difficulty in accounting for the valence of three, but complications arise when we begin to consider the compounds in which these elements have an apparent valence of five. In the first place, we have stated that electrons are always shared in pairs and, in the second place, that eight electrons constitute the maximum for the valence shell of any atom. Either of these stipulations would limit to four the number of atoms which could be joined to any other one atom. How then shall we account for the existence of such compounds as $H_3PO_4$, $NH_4OH$, etc.?

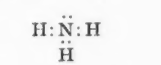
The simplest and apparently the most logical explanation seems to lie in assuming, as Professor Lewis[7] does, that the two means of chemical

[6] An atom which has gained, lost, or shared an electron or electrons, but not enough to arrive at the stable octet structure, is said to be in an "unsaturated state."

[7] *Op. cit.*, p. 100.

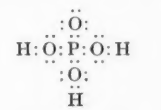
combination—shared electron pairs and electrostatic attraction—may occur simultaneously in the same compound. Accordingly, he would assign the following structures to $NH_4OH$ and $H_3PO_4$, respectively:

The case of ammonium hydroxide is particularly interesting. Here it is assumed that ammonia, a saturated, neutral compound, can add a hydrogen ion to form a stable positive ion, which can then, of course, attract an hydroxyl, or other negative ion, to form ammonium hydroxide, or some other ammonium compound. This assumption is rather startling in the light of earlier ideas concerning chemical combination, yet when we consider that the ammonia molecule,



possesses an unshared electron pair which might easily prove attractive to a hydrogen ion (*i. e.*, a lone proton), the idea becomes plausible.

It is probable that the foregoing formula for $H_3PO_4$ represents only an extreme view and that the true state of affairs is something in the nature of a compromise or an equilibrium between that diagram and the following:



Here the hydrogen ions should not be considered as firmly attached to any particular oxygens but as free to migrate from one to another or to separate completely (*i. e.*, to "ionize").

We are now brought face to face with the question which began to arise during our discussion of ammonium hydroxide—just what is valence? Let us examine some of the more commonly accepted definitions.

(1) Valence is the capacity of an atom to hold other atoms in combination, and is measured by the number of atoms of hydrogen (or its equivalent) held or displaced by one atom of the element in question.[8]

(2) The positive valence of an element in combination depends on the number of electrons which its atom has lost. The negative valence of an element in combination depends on the number of electrons which its atom has received.[9]

[8] "Introductory College Chemistry," Harry N. Holmes, The Macmillan Co., New York City, **1925,** p. 64.

[9] "Principles of General Chemistry," Stuart R. Brinkley, The Macmillan Co., New York City, **1925,** p. 17.

(3) The writer has also heard it said that "the valence of an atom in combination is measured by the number of bonds which it forms with another atom or other atoms."

(4) Still another system of determining the valence of an atom in combination (but one which is not ordinarily phrased in the form of a definition of valence) consists in computing the algebraic sum of the "positive" and "negative" equivalents of the atoms with which it is combined. The result with sign reversed is taken as the valence.

It is instructive to apply these various views in an attempt to answer the question: "What is the valence of nitrogen in ammonium hydroxide?"

According to the first definition we must answer that nitrogen has a valence of *five*, for it is combined with four hydrogen atoms and one hydroxyl radical, which is properly considered as a unit and equivalent to a hydrogen.

The second definition, or pair of definitions, is a little more difficult to apply to the case in hand. It is so worded as to imply that chemical combination must be accomplished through a complete gain or loss of electrons, whereas in ammonium hydroxide we know that the electrons must be shared rather than completely transferred. If, however, we broaden the sense of the definition a little by considering that electrons "lost" can apply to electrons either given up entirely or furnished to shared electron pairs, and that electrons "gained" can include electrons furnished by other atoms to form shared pairs, we can proceed. On this basis we find that we obtain two answers, as a glance at Figure 4 will show. Here the electrons furnished by the nitrogen are represented by solid black circles and those furnished by the hydrogens by white-centered circles. Thus we see that, according to definition (2), nitrogen in ammonium hydroxide has at the same time a positive valence of *five* and a negative valence of *three*.

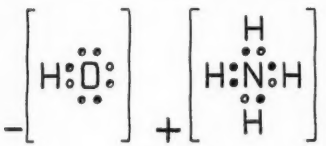
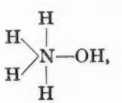


FIGURE 4

The third definition can also be made to give two answers, though not two simultaneous answers. If we write the structural formula for ammonium hydroxide in the good old-fashioned way,



without bothering our heads about electrons, and consider each dash as a "bond," we must say that nitrogen has a valence of *five* in this compound. If, however, we prefer the more modern and apparently more correct formula of Professor Lewis (as in Figure 4), and if we define the "bond" as a shared electron pair, we are forced to the unorthodox conclusion that the nitrogen atom has a valence of *four* in ammonium hy-

droxide. Professor Lewis, himself, does not hesitate to pronounce nitrogen tervalent in compounds of this kind.[10]

The fourth system can be applied in two ways, depending upon whether the OH radical is considered as a unit or whether the O and the H are tallied up separately, but it gives the same result in either case, as a comparison of the columns below will show:

| | |
|---|---|
| 4 H = +4 | 5 H = +5 |
| 1 OH = −1 | 1 O = −2 |
| net equivalents = +3 | net equivalents = +3 |

Since the net equivalents of the atoms combined with nitrogen are +3, nitrogen must have a valence of −3 in this case.

In applying four very common definitions of valence to the determination of the valence of one compound we have arrived at the following answers: 5, −3, +5, and 4. The reader is at liberty to select the definition which best pleases him or to frame a new one of his own. However, he should not draw from the foregoing discussion the conclusion that all our ideas concerning valence are confused and hazy. It is only when we encounter a peculiar compound like ammonium hydroxide that our definitions begin to disagree among themselves; ordinarily they give concordant results, as a little reflection will show. The morals of this little tale (if it contain any moral at all) are two:

(1) *air-tight definitions are mighty hard to construct;*

(2) *a lot depends upon the point of view.*

[10] *Op. cit.*, p. 106.

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## STUDENT CONTRIBUTIONS

Is your chemistry club carrying on some worthwhile project? Have you, yourself, an interesting chemical hobby? Have you devised an original chemical experiment or piece of apparatus? Have you built a working model of a chemical plant or a piece of chemical machinery? Have you a chemical collection of any kind?

Tell us and other students about it in an article of not more than one thousand words. If possible, illustrate your article with drawings or photographs, or both. In preparing your manuscript, observe the directions to authors set forth on page 1366.

Ten dollars will be awarded the high-school or undergraduate college student contributing the best item received on or before November 15, 1928. Five dollars will be paid for any other articles accepted for publication. Address your contribution to the Associate Editor, JOURNAL OF CHEMICAL EDUCATION, the Johns Hopkins University, Baltimore, Md.

## ALFRED NOBEL, INVENTOR OF DYNAMITE*

At the mention of dynamite, are you confronted with a picture of the destruction caused by explosives in general during the World War, or do your thoughts follow along more constructive lines, visualizing bridges, tunnels, or skyscrapers, which are made possible only through the aid of this and other explosives? Explosives may be, on the one hand, formidable materials of war and, on the other, powerful auxiliaries of peace. Hence, it is not altogether incongruous that Alfred Nobel, who devoted the major portion of his life to perfecting explosives, should have been an ardent lover of peace.

ALFRED NOBEL

Alfred Nobel was born in Stockholm, October 21, 1833, the third son of Emmanuel Nobel, a Swedish inventor. It is related of Emmanuel Nobel that at the age of six he discovered he could light his father's pipe by means of a lens of ice; several years later he escaped from the top floor of his home, where he had been sent for punishment, by making himself a parachute from an old umbrella and piece of string; at eighteen he designed and erected a triumphal arch which won him admittance to the Academy of Fine Arts at Stockholm; at twenty-six he became associate professor of descriptive geometry at the Technical School in Stockholm; and during the next ten years produced such creditable experimental work on explosives and torpedoes that the Russian government provided him with means to perfect his torpedoes. Small wonder, then, that his son, Alfred, exhibited a certain degree of talent along similar lines.

Alfred's schooling in Stockholm lasted only one year, for in 1842 his family moved to St. Petersburg, Russia, where Emmanuel Nobel had already established a plant and foundry for the construction of land and submarine mines, and the investigation of explosives. In these labora-

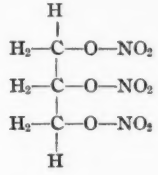
* Material for this article was obtained from "Alfred Nobel, Sa Vie et Ses Travaux," P. T. Clive, P. A. Nordstedt & Sons, **1904**, Stockholm, Sweden.

tories and shops, the sons learned the use of tools and scientific apparatus.

At the age of 16, Alfred was sent to America to study the engines of John Ericsson, the great Swedish-American engineer and inventor. Returning to Russia in 1854, already a trained engineer, he resumed his investigational work in his father's laboratories. His earlier patents—(1) for a gasometer, based on the determination of the quantity of water which the gas will absorb,[1] (2) an apparatus for measuring water and other liquids,[2] and (3) improvements for barometers[3]—indicate the diversity of his interests at this earlier period.

At the close of the Crimean War, the Russian government began to favor foreign companies with the orders previously given to the Nobels, with the result that the factory went into the hands of receivers. The eldest son was given the administration of the works and Emmanuel with his two younger sons returned to Sweden in 1860. These men possessed an indomitable perseverance which obstacles and misfortunes could not overcome. They continued their investigations of explosives, and found in nitroglycerine a substance with the aid of which they hoped to repair their damaged fortunes.

The Italian, Sobrero (1812–88), a pupil of the famous Pelouze, at Turin, had prepared nitroglycerine (or Nobel's "blasting oil" as it was later designated) by dropping nitric acid on glycerine. The formula for nitroglycerine, which, strictly speaking, should be called glyceryl nitrate, is:



It is said that in the Avigliana Nobel Dynamite Plant near Turin, there is still preserved 200 grams of the first nitroglycerine made by Sobrero, a sample of it being tested annually.

At first, the liquid state and poisonous properties of the substance seemed likely to prevent its general use indefinitely. Its practical importance was finally realized only because of the heroic courage and unshakable determination of Alfred Nobel. In 1862, having obtained financial backing from a Paris banker, he erected a small plant at Heleneborg, near Stockholm, where nitroglycerine was made on a larger than laboratory scale for the first time. During the next few years the work

[1] British patent, No. 2507, Sept. 29, 1857.
[2] British patent, No. 177, Jan. 20, 1859.
[3] British patent, No. 556, Mar. 2, 1859.

of perfecting the manufacture and use of nitroglycerine on a commercial scale, and of overcoming the dangers attending both, progressed. However, this progress took its toll of lives when on Sept. 3, 1864, a terrific explosion destroyed the laboratory at Heleneborg, killing several persons, including Alfred's younger brother and the chief chemist, Erik Hertzman. Emmanuel Nobel received injuries which finally resulted in his death in 1872.

The manufacture of nitroglycerine in thickly populated districts was prohibited because of this accident, but such unpopularity did not discourage Nobel. He installed the works on a barge anchored in a stream at some distance from the shore and changed his position as often as protests from the vicinity necessitated. Gradually a demand for Nobel's "blasting oil" developed and plants were established in Sweden, Norway, and Germany during the next few years.

The liquid form of the "blasting oil" led to accidents in transportation and use as the product was gradually introduced to trade. By chance, upon unpacking a case of tins from the Krümmel factory in Germany, Nobel noticed that some of the packing material, kieselguhr (a porous and siliceous earth), resembled a thick mortar. Upon investigating, he found a leak in one of the tins. Nobel found this mixture to be less sensitive to shock than the liquid form, and this new product—named dynamite—was quickly adopted. Dynamite, later called guhr-dynamite, was patented in Sweden, September, 1867, and attained universal fame in a very short time. It became impossible to meet the demand for it, and factories were established at many points in Europe and America. Thus, by 1873, the happy idea of Emmanuel Nobel, Alfred's father, of introducing nitroglycerine into commerce and industry was realized, but the price of its triumphal march had been heavy.

At this time Nobel decided to establish his residence in Paris. He continued his experiments upon dynamite, seeking to replace the inert kieselguhr with some substance which could take part in the explosion. Here again chance favored him. Working in the laboratory one day, he protected a cut in his finger by covering it with collodion. This suggested using collodion solutions with the nitroglycerine and the result of his experiments was the patenting, in 1876, of a product, named dynamite gum, which far surpassed its predecessors. We do not mean to convey the impression that Nobel's most important discoveries were products of accident. Though he quite often made use of materials at hand, it was due to his systematic and scientific method of investigating any problem that his efforts were rewarded with success. Other investigations developed the smokeless powder, called ballistite or Nobel powder, which was patented in 1889. During this period Nobel was also working on the construction of pieces of ordnance and general artillery equipment and took a keen interest in the Baku oil fields in Russia.

In 1888, at the death of his brother in Russia, Nobel realized his unpopularity in the French capital, for the journals had mistakenly announced his own death. Although the German and English publications voiced their appreciation of the value of his researches, the French journals vigorously attacked him for his failure to offer his smokeless powder to the French government, instead of to that of Italy in 1887. (They ignored the fact that this had been done but the French government decided to retain the Vieille powder which it had just adopted.) The outcome of this criticism resulted in Nobel leaving Paris in 1891, and establishing his laboratory and residence at San Remo on the Mediterranean, where he died quite suddenly on December 10, 1896, busy to the last with research on new problems. Singularly enough, several weeks before his death, the medicine prescribed by his physicians for his heart condition was none other than dilute nitroglycerine.

During his lifetime Nobel had taken out 129 patents, proving his activity as an inventor. Suggestions concerning numerous other possible inventions were noted down "for the use of those who have leisure." Nobel's sensitive timidity caused him to shun rewards and honors. He seems to have appreciated, however, his membership in the Legion of Honor of France and his nomination as Doctor *honoris causa* by the University of Upsala on the occasion of its jubilee in 1893.

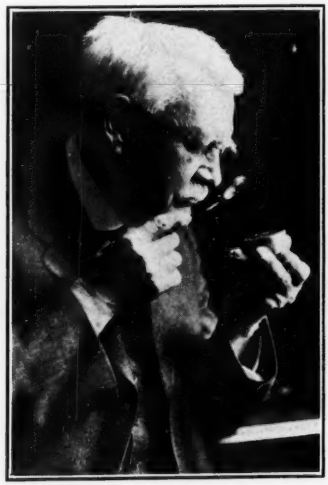
A man free from prejudices and with the heart of a philanthropist, his amiable and understanding nature was appreciated by all with whom he came in contact. He excelled in the art of conversation, not only in his mother tongue but also in French, German, Russian, and English. He possessed a keen literary instinct, and his library affirmed his cosmopolitan tastes. He was also interested in paintings, but tiring of too long contemplation of any of them, he arranged with a Paris merchant to periodically exchange those in his residence.

Passionately fond of work himself, he believed that work was the true source of happiness and that great fortunes acquired by inheritance were an injustice to the recipient. As a natural consequence of this attitude, we find that Nobel's immense fortune amassed from the manufacture of dynamite and other explosives, and the development of the Baku oil fields, was bequeathed to a cause and not an individual. Pasteur's words —"It is ignorance that separates men, and science which draws them together"—influenced Nobel in dedicating his money to the causes of universal peace and the advancement of science. The Nobel Foundation was established at Stockholm on June 29, 1900. Yearly, in the fields of physics, chemistry, physiology and medicine, literature, and peace, five prizes of about $40,000 value each, are awarded to those persons who have, during the year preceding, contributed most materially to human advancement.

# MOLECULAR SPEED

R. E. ROSE, E. I. DU PONT DE NEMOURS & CO., INC., WILMINGTON, DELAWARE

Air is a mixture of molecules. These are moving very fast. On a frosty day their average speed is about one-quarter mile each second or 900 miles an hour. When they move 935 miles an hour you feel comfortably warm, when they race 951 miles an hour you feel disagreeably hot. These are the little things that make or unmake our happiness.



*Photos by Science Service, reproduced by courtesy of Ind. Eng. Chem., News Edition*

THE MUNROE EFFECT IS A DEMONSTRATION OF HIGH MOLECULAR SPEED

One of the most impressive demonstrations of high molecular speed is the phenomenon known as the Munroe effect, whereby tracings of leaves, lace, and other delicate patterns can be reproduced upon the hardest steel by the firing of charges of high explosives.

At left, Charles E. Munroe, explosives expert, U. S. Bureau of Mines, examining piece of chrome steel with portrait reproduced by Munroe effect. At right, Munroe effect produced by firing high nitro-gelatin explosive over piece of chrome steel, with photograph in between. Portrait reproduced is of Charles E. Munroe, discoverer of the effect.

You do not feel the air molecules strike you but you feel the effect they have on the activity of the molecules of your body. On a very moist hot day you are particularly unhappy because you cannot lose the lively water molecules from your skin, leaving the cooler ones behind.

It is amazing what a speeding up of molecular motion will accomplish. A stick of dynamite, that most useful of modern conveniences, is nothing

more than a package of molecules that can be caused to turn into others moving with a velocity that amounts to three-quarters of a mile per second. The molecules in the dynamite are built like a top-heavy house with weak members. The nitroglycerine and the ammonium nitrate are just in this condition, give them a knock and over they go, only the knock has to be of a particular kind to make sure of results. But the fragments of molecules are new molecules and these do not settle like the dust from a falling house, they fly in all directions, spurred on by the energy which was tied up in the explosive materials.

The farmer, blowing up a stump, takes a fuse which contains fulminate of mercury, a frightfully sensitive kind of molecule. He fits this on a fuse, crimps it tight, takes a stick of dynamite and makes a hole in it into which he shoves the cap, then, the fuse being fastened, he puts the dynamite in a hole under the stump, puts more sticks of dynamite in, then rams them home, and covers them with earth. Then he starts the molecules moving. Those on a match head get lively enough when excited by the heat of friction on his pants, the match stick starts burning, the molecules of the flame upset the molecules in the fuse. Then the farmer runs to shelter and the next moment the spurt of fiery molecules from the fuse hits those of the fulminate in the cap. Away they go smashing the metal cap to pieces and hitting the dynamite a knock-out blow, the whole mass topples to pieces and the pieces push against the earth and against the stump—up goes the stump, lifted by particles of which forty million edge to edge would measure only one inch.

The control of molecular speed is the underlying fact upon which our civilization is built.

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**Prospecting for Minerals in Sub-Arctic Regions.** Equipped for a two years' stay in Canada's sub-Arctic regions and with airplanes for prospecting, a party of Canadian mining engineers and geologists has sailed from Halifax in the schooner *Morso*, bound for points in Hudson Bay. The expedition which is sent out by the Dominion Explorers, Ltd., is under the direction of Mr. C. H. Blanchet, exploratory engineer of the Canadian Department of the Interior, who is on leave of absence for the purpose. Equipped to be self-supporting and to venture beyond the tree belt into the so-called "barren lands," the expedition carries two "Fairchild" and two "Moth" airplanes, fitted with both pontoons and skis, besides specially constructed river boats known as "sturgeon heads" and snow-mobiles, or motor cars equipped with skis forward and giant flanged wheels on the rear axles. The engineers believe they will unearth mineral resources of vast value, which may be exploited with profitable facility on the completion of the Hudson Bay railway. Lieut.-Commander J. T. Randall, D.S.O., a retired officer of the British Navy, of Liverpool, Nova Scotia, is in charge of the *Morso*, a schooner of 400 tons, equipped with powerful auxiliary motors, wireless, and modern navigation aids.—*Chem. Age*, **19**, 32 (Oct. 6, 1928).

## SVANTE ARRHENIUS AND THE THEORY OF IONIZATION

The theory of ionization has become so fundamentally and essentially a part of modern chemistry that we find it hard to visualize a time when it did not exist. We feel instinctively that it must belong to comparatively ancient chemical history. Yet the man who really "put across" the theory of ionization died so recently as October of last year. Scarcely a genera-

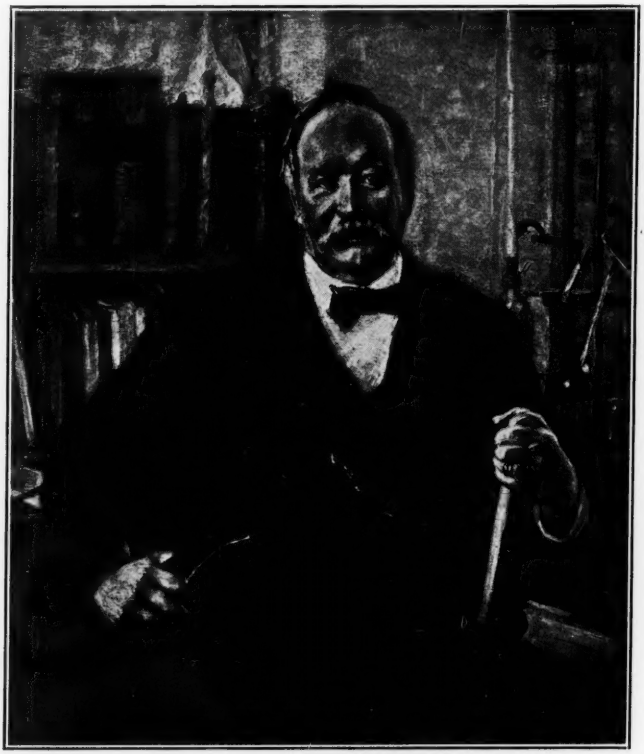


*Photo loaned by W. M. Blanchard*

SVANTE ARRHENIUS

tion ago ionization was a scientific heresy and there are still living men who attacked it vigorously at that time.

Even in science, where the open mind is most highly acclaimed, there is always a large orthodox faction. Be it said in favor of scientists, however, that once the supposed heretic has proved his case, he is highly honored as a pioneer and a discoverer. This was true of Arrhenius. He was eventually called to America to deliver the Willard Gibbs memorial

lectures at Yale and in 1911 was presented with the Willard Gibbs medal of the American Chemical Society.

Upon the occasion of the presentation of that medal he related many of the incidents connected with the formulation, publication, and defense of his theory. The text which follows is extracted from his acceptance address.[1]

After some preliminary remarks in appreciation of the work of Willard Gibbs, Arrhenius proceeded:

. . . .

"Now, after I had this great honor to be, in a certain degree, connected with the place where Willard Gibbs had worked, I came here to take this great honor, again connected with his name, and I must say it is the greatest honor that can be conferred upon me and it touches me more than anything else could do. I have, according to the statutes regarding this medal, to give an address regarding the subject for which it has been given. I must say that Dr. Smith has spoken so eloquently on that before, that it will be a great trouble to me to try to make it better, and I fear I will not be able to do that. I may nevertheless perhaps appeal to your kind interest by telling some of my personal dealings and views of that time.

" 'There is nothing new under the sun'—I believe it was King Solomon who said that, and it is true, absolutely so, today, and will remain so; there were some forerunners also regarding the dissociation of salts into their ions, such as sodium chloride into sodium and chloride ions in solution. It had been found that if we investigated the physical properties, especially of different salts in their solutions, if we took them in so-called equivalent proportions in the same quantities of water, then these properties show a very remarkable degree of regularity, they are called additive; they behave absolutely as if the properties could be described as the sum of the properties of the parts of the salt, at that time called radicals, now called ions, so that the properties could always be ascribed, as due for one fact to the one part of the salt, and for another fact to the rest of the salt, and then for the rest due to the solvent. . . . .

". . . . This idea seemed absolutely impossible; it could not be accepted. Everyone knows that if we dissolve salt in water, the solution has a salty taste, but it has not at all the properties of sodium; for sodium is a metal and is not soluble in water, except in the form of the hydroxide. Further, it has not at all the properties of common chlorine; because common chlorine gives a very disagreeable odor to water, and also a green shade to its color, and tastes extremely disagreeable and is poisonous. It is clear that if sodium chloride is dissociated into sodium and chlorine in

[1] "Electrolytic Dissociation," *J. Am. Chem. Soc.*, **34**, 353–64 (1912).

the water, it must be something else than the common chlorine and common sodium, but this conclusion seemed hard for most chemists. . . .

". . . . I had to work out a thesis in order to get a doctorate; that was in 1882—I had come so far then. The opportunities for working it out in my home university, Upsala, were not favorable, therefore I went to Stockholm. . . .

". . . . There was already then a large amount of work in that line and my contributions were only a small part of what was known. But my great luck was that I investigated the conductivity of the most dilute solutions. In these dilute solutions the laws are simple compared with those for concentrated solutions, which had been examined before. It was then easy to find that the irregularities, which came in every step with the concentrated solutions, disappeared. The whole thing was very simple, but it was necessary to believe that the conducting molecules which, according to Clausius, were dissociated, that these conducting molecules were the whole part of the dissolved salt in this high dilution. I knew my professors in Upsala too well and found that it would be impossible to get them to believe that. Therefore, if I had made such a statement in my doctor's thesis, it would not have been approved, so that I would have had to work on a new thesis before I could be nominated doctor.

"Therefore, I did not say that there is a nearly total dissociation of salts in their highly diluted solutions, but I said that the salts consist of two different kinds of molecules in solutions, the one inactive—this expression did not look so dangerous—and the other active. These latter conduct electricity, and the others, the inactive ones, do not. In the highest dilution all molecules are active, and I said further that the molecules which are active are in the state described by Clausius; he was a great authority, therefore it could not be unwise to share his ideas. Interesting as the electrical conductivity is, it seems of a secondary interest from a chemical point of view. But a study of Berthollet's work on thermochemistry showed me that those acids which conduct electricity the best are also chemically the strongest and always displaced the weak acids which do not conduct electricity or only conduct it poorly. With different acids the differences of conductivity are such as one to one million, in many cases. Therefore, the determination of their order regarding conductivity is very exact. It was now quite clear to me that there were no exceptions to the rule that, of two acids, that which had the better conductivity in equivalent solutions in a given solvent was also the stronger acid. The next step was also quite clear: the active molecules, which are active in regard to electricity, are also active in regard to chemical properties, and that was the great step. . . .

"Then I arrived at another conclusion, namely, that if two electrolytes react upon each other, they give only reactions of the ions and do not

give anything else. For instance, potassium ferrocyanide, which contains potassium, iron, and carbon and nitrogen in the form of cyanogen, does not give reactions of iron or cyanogen, for these ions are not the ions of this salt; but its ions are potassium and the rest of the molecule. In all cases the one ion is the metal, and the other ion is the rest of the molecule. And this rest is not iron or cyanogen and therefore the potassium ferrocyanide does not show any reaction of iron or cyanogen. As it was called before, the 'type' of the salt was 'conserved' in this case, the 'type' of ferrocyanides. So, if we may allow potassium ferrocyanide to react on another salt, then always a ferrocyanide, that is, a salt of the same type, is formed. This 'conservation of types' could not be explained before. I had, in this manner, deduced a rather great number of different properties which had not been explained before; but I must say that this circumstance made no very great impression upon my professors in Upsala.

"I came to my professor, Cleve, whom I admire very much, and I said: 'I have a new theory of electrical conductivity as a cause of chemical reactions.' He said: 'That is very interesting,' and then said, 'Good-bye.' He explained to me later, when he had to pronounce the reason for my receiving the Nobel prize for that work, that he knew very well that there are so many different theories formed, and that they are all almost certain to be wrong, for after a short time they disappear; and, therefore, by using the statistical manner of forming his ideas, he concluded that my theory also would not exist very long.

"I was not very content with that opinion, and then I thought, in foreign countries there are such prominent scientists, they might look at it differently; it might appeal to them. Then I wrote to Clausius, and said: 'What do you think of that?' I wrote to Ostwald—he worked on the same line. I wrote to Thomsen. I received friendly answers from most of those scientists, and they were very glad to make my acquaintance, and so on, but it was not very much more. The only exception was Ostwald, and he describes, himself, how it was that he got on the same day this dissertation, a toothache, and a nice daughter, and that was too much for one day, and the worst was the dissertation, for the others developed quite normally. But this bulky dissertation was very hard for him, and he said there were indications that some of its parts were not quite in order. There were some unfamiliar expressions and sanguine ideas, but, finally, he found it still might be good to look into, if it was true. He had a great number of acids which he had investigated regarding their chemical reactivity, that is, regarding their chemical strength in catalytic reactions, and then he investigated them in regard to their conductivity, which was done very rapidly. He found that their chemical activity and their electrical conductivity were nearly proportional to each other. Then he came to see me personally, and spoke with me, and we

had some very pleasant days together, and then we made plans regarding the development of the whole of chemistry. Everything seemed to us so regular and fine, and we have really developed that program for the most part; but I must say that the reality has been much better than we believed at that time.

"Then Ostwald, of course, visited my dear friend and teacher, Cleve. Ostwald spoke to him one day in the laboratory. I came a little later. I was not expected, and then I heard Cleve say: 'Do you believe sodium chloride is dissolved into sodium and chlorine?' 'In this glass I have a solution of sodium chloride; do you believe there are sodium and chlorine in it?' 'Do they look so?' 'Oh, yes,' Ostwald said, 'there is some truth in that idea,' and then I came and the discussion was at an end. I was very sorry for that.

". . . . After some years, our opponents did not attack us any more, but still they showed a passive resistance, which all of you know is much more difficult to conquer than an active one. All of them hoped that some one would come to demonstrate that we were on the wrong path. This situation became too long and tiresome for Ostwald. He said: 'Let us attack them, that is the best method.' He wrote a very severe criticism of the opponents' memoirs in his journal, and he said openly that they did not understand anything regarding physical chemistry. Thereupon the opponents gave their assistants and other pupils, who were going to make investigations, subjects to treat of which they hoped would show that we were not right, and said that we were unable to explain them. But, in reality, it was always easy to find an explanation founded on the new theories of solutions, whereas no explication was given from the other side. In that manner, from our own side and from the opposition, a great deal of material favorable to the new theories was soon collected.

". . . . So it came about very rapidly that the new dissociation theory was in the majority and not in the minority, as before. I am glad to say that this work continues still today, and that especially Americans are working on the old classical lines; here are a great many laboratories where the old traditions are prevailing, more than in any other part of the world, even in Germany. Van't Hoff is, I am very sorry, dead, and Ostwald has left chemistry and gone into other branches of science, and still more of philosophy. Now the dissociation theory is brought to a certain degree of completeness—certainly there is much left to do in it—and we treat with a very great degree of accuracy a very great number of questions regarding solutions. . . .

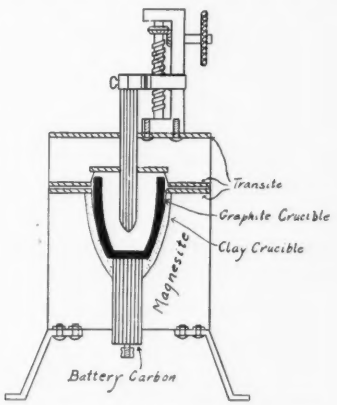
"Now, in receiving this medal, struck in honor of our great master, Willard Gibbs, I wish to express the hope that very many members of this Society, and colleagues of mine in this case, shall receive this medal in the coming years. I thank you very heartily."

# A HOME-MADE ELECTRIC FURNACE*

JOHN KISSEL, MARYHURST NORMAL, KIRKWOOD, MISSOURI

Melting substances, especially metals, always had a kind of fascination for me. When working in the chemical laboratory, I was always glad to have assigned to me an analysis which involved a fusion of some sort, even though I had grave doubts about my ability to unscramble the melted mess. In our school laboratory, we have only gas-heated appliances for melting substances, and I often wondered how an electric furnace would do the job. Such a furnace is not really essential to our work, and our laboratory appropriations are not sufficiently large to enable us to invest in non-essentials at this time, so there was but one thing to do if I wanted an electric furnace, and that was to make one.

There were three types of electric furnaces to choose from, the induction, the resistance, and the arc type. With the first I was not yet sufficiently acquainted. Of the other two, the arc furnace gives the higher temperature, and I am for high temperatures, so an arc furnace it was to be.




CROSS-SECTIONAL DIAGRAM OF THE FURNACE

I began with a humble tin can—a number ten molasses can, to be precise. I cut away the upper third, and, with a can opener, cut an artistic circle out of the bottom, leaving only about a quarter of an inch around the edge. Into the can I fitted a piece of one-eighth inch Transite, having a circular hole about two inches in diameter cut in the center. This was to be the upper side of the furnace. A clay crucible was then commandeered from the laboratory stock, and its bottom carefully cut away so that it would fit snugly over a carbon rod about an inch in diameter, which had been inherited from a defunct dry cell. This rod was made to protrude a short distance into the clay crucible. The furnace shell was then turned upside down, and the clay crucible, holding the carbon rod, was cemented to the transite top with retort cement. A little more cement was placed around the juncture of the carbon rod and clay crucible for greater rigidity and then the entire furnace was filled with magnesite, which a considerate boiler repair man had left behind. Another can

* Winner of ten-dollar award in the student contribution contest closing October 15, 1928.

bottom was obtained and a small hole cut in its center to permit the carbon rod to pass through. Three legs, fashioned from brass strips, were bolted to this bottom, which was then soldered onto the furnace body. The carbon was already provided with a good binding post and so this part of the furnace needed nothing further.

Now came the cover, equally important. The shell was prepared in the same manner as that of the furnace body, but was only about two inches deep. Another Transite disc, with a two-inch hole in the center, was fitted into this, and a flat cork of the same diameter fitted into this hole. A piece of half-inch brass tubing was forced into the center of the cork, penetrating it for about a quarter of an inch. On the cork came a Transite washer, which was to serve as the top of the crucible chamber. Cork, tube, and washer were then covered with retort cement, and the rest of the furnace lid filled with magnesite. A third Transite disc, to which the carbon holder had been firmly bolted, was then placed on top of the lid and held in place in the same manner as the other discs. The carbon holder had been adapted from an old arc light, a relic of the days before incandescent lamps were used for projection purposes. It served the purpose admirably. The cork and brass tubing were now carefully withdrawn and my furnace was complete.

And now for the tryout. The last user of the stereopticon arc light had considerately left the carbons in the clamps, for which consideration I was duly grateful. I put the stereopticon rheostat in series with the furnace, dropped a couple of ingots of brass into the crucible and turned on the current. It worked like a charm. The brass was melted in two minutes.

I then filled the crucible with finely divided silver, which had been reclaimed from the laboratory waste jar. This did not behave so well. It took considerable time and some coaxing, but finally it also melted.

This is as far as my electric furnace experience goes, up to the present. It isn't far, but it is enough to show me that my furnace works, and that is the main thing. Already I see a number of ways in which my furnace can be improved. And dimly, and, as it were, in the distance, I see the faint outlines of an induction furnace. When dreams come true, I may tell you about that one.

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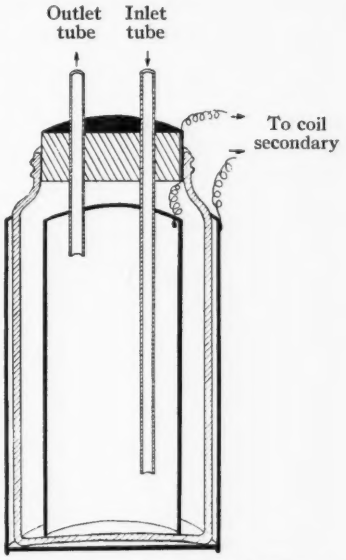
**Snail Mine to Be Worked.** An interesting natural phenomenon in Stevens County, Washington, is about to be put to commercial use. For want of a better name it is tentatively called a snail mine. Under a shallow lake covering about forty acres is a bed of freshwater molluscs, small creatures inhabiting shells shaped not unlike those of snails. This bed is about 18 inches deep, and beneath it there appears to be about 80 feet of the same material dead and decomposed over a period of some centuries. It contains nitrates, phosphate, and potash. "Jim" Hill, railroad builder, told about the deposit years ago. A syndicate is now preparing to ship the stuff.—*Mining Truth*

# AN EASILY MADE OZONIZER*

MALCOLM MAXWELL, NORTHWESTERN STATE TEACHERS' COLLEGE, ALVA, OKLAHOMA

Last year the author and another boy were given the problem of constructing a cheap and simple ozonizer from old tin cans, jars, and so forth. The main requisites were that it be constructed of commonplace materials, and capable of being easily duplicated by persons possessing neither specialized tools nor unusual mechanical ability.

After a little preliminary experimentation, an apparatus which gave excellent results was constructed. It was used in a lecture demonstration by the instructor, who declared it to be much simpler and easier for first-year students to understand than the commercial ozonizer. It has the further virtue that the student can duplicate it easily at home.




CROSS-SECTION DIAGRAM OF OZONIZER

It was found that the details of construction and material were capable of considerable variation without deleterious effects on the functioning of the apparatus.

The ozonizer proper may be made from two tin cans, a glass jar, a two-hole stopper to fit the jar, two short pieces of glass tubing, and two pieces of wire. To construct it, first procure a wide-mouthed glass bottle or jar. A pint fruit jar works very well. Next find two tin cans, one to go on the outside of the jar and one to go on the inside. Theoretically, the smallest can that the jar will go into should be used for the outside can, while the largest can that will go into the jar should be used for the inside. Cut off the bottom of the inside can, and cut both cans so that the mouth of the jar extends a little above them.

A large two-hole stopper to fit the jar is required. A rubber stopper is best, but cork boiled in paraffin should do. A nearly air-tight fit is required here, if the ozone is to be conveyed away for use. A long and a short glass tube are placed in the holes to act, respectively, as an inlet for untreated air and an outlet for ozonized air. The long tube should extend nearly to the bottom of the jar. We found it unnecessary to intro-

* Winner of a five-dollar award in the student contribution contest closing October 15, 1928.

duce the incoming air between the jar and the inside can. A suitable length of wire is attached to each can; soldering, of course, is best. The cork must be notched a little to admit the wire leading to the inner can. This completes the ozonizer, itself, but certain accessories are required for its operation.

For the coil we used an old Model T Ford coil, which was easily obtainable and gave excellent results. An automobile pump served to deliver the necessary air current. The use of lung-power is not only arduous but introduces moisture which puts the apparatus out of commission.

If lighting current is to be used a step-down or "bell-ringing" transformer is necessary. Any source delivering current at six to twelve volts is satisfactory.

Connect up the apparatus, turn on the current, adjust the spark coil, and begin to pump. The odor of ozone will soon be apparent. The presence of ozone in the effluent air may also be demonstrated by chemical means, for ozone turns a starch-iodide solution dark blue.

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## AN EDUCATIONAL FABLE*

There was once a rough and uneducated man who had made money and who entered his boy in a swell college preparatory School. The Head Master asked him if there was anything that he was particularly desirous that his son should be taught, and the Uncultured One replied: "Yes, there is. I want him to take Greek."

"May I ask," inquired the Head Master, in considerable amazement, "why you are so insistent upon his pursuit of that particular subject?"

"Well," said the Rude parent, "there are Three reasons why I want him to learn Greek: First, because it's hard; second, because he don't want to; and third, because it's no good anyway. If he learns it after all that, he'll show he's got some stuff in him."

Moral: *This fable has morals enough to fill a book.*

*From "Educational Fables." Edward C. Durfee, *Scribner's*, **84**, 329–33 (September, 1928).

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**Paints Ice to Open Channel.** Lake Labarge, locale of the strange goings on in Robert W. Service's poem, "The Cremation of Sam McGee," was the scene of an unusual operation against low temperature recently when a steamboat captain painted a black streak across the ice to hasten its melting and thus permit an early voyage from White Horse to Dawson, Alaska.

Remembering from his school book physics that black absorbs the sun's rays and retains heat, H. Wheeler, owner and captain of the steamboat *Casca*, and his crew smeared a strip of refuse oil and lamp black forty feet wide across the glittering ice of Labarge.

A report of the venture received here said the application caused the ice to melt sooner than the glistening expanse that had not been painted. The *Casca* was said to have sailed through the 29-mile canal etched in the ice by the oil and lamp black and moved toward Dawson.—*Philadelphia Bulletin*

## Correspondence

### "DECEPTIVE ADVERTISEMENTS"

My attention has been called to an article in the July, 1928, number of the JOURNAL OF CHEMICAL EDUCATION entitled "Deceptive Advertisements."

The article, written by Charles F. Mason of Mt. St. Mary's College, Emmitsburg, Md., severely criticizes a product which I recognize as one devised by me for the generation of hydrogen sulfide gas for analytical work.

The product consists of an intimate mixture of sulfur, paraffin wax, and asbestos. The paraffin wax and sulfur are present in very nearly the stoichiometric proportions required by the equation:

$$C_nH_{2n+2} + (n + 1)S \rightarrow nC + (n + 1)H_2S$$

$n$ being regarded as a large number, so that the ratio $(14n + 2)/32(n + 1)$ becomes 0.438. The asbestos, which is used as a vehicle for the reactants and as a means of preserving a desirable texture, is in such quantity (50% of the mixture) as has been found by experience to give the best results especially as regards retention of the reactants in the mass upon applying heat.

The error to which some users of this material are prone is that they heat the material, recklessly distilling the reactants from the mass before the chemical action has taken place. This is what Professor Mason did. Obviously this is to be avoided. And it can readily be avoided if directions be faithfully followed.

We took ten grams of the batch of material of which Professor Mason received a sample from us and packed it in a 6-inch Pyrex test tube fitted with a singly bored rubber stopper and delivery tube leading directly to a flask containing a solution of sodium hydroxide. The $H_2S$ evolved on heating was absorbed by the NaOH solution. While we avoided heating so rapidly that Professor Mason's "yellow mist followed by a dark brown one" was expelled, nevertheless the heating was conducted so rapidly that when we had reached the front of the charge a quantity of melted paraffin had been driven to the forward part of the tube.

The NaOH solution containing the expelled $H_2S$ as $Na_2S$ was diluted to 1 liter and aliquot parts of 25 cc. each were diluted, acidified, and titrated with standard iodine solution; and added to excess of lead acetate solution. We weighed the lead as $PbSO_4$. The results calculated to the 10 grams of material taken were 619 cc. and 594 cc. $H_2S$ gas.

Professor Mason's results were 608 cc. per 10 grams of material by measuring the volume of evolved $H_2S$ gas and 588 cc. by precipitating and weighing PbS.

Next we repeated the experiment introducing a wash bottle of water between the generator tube and the NaOH solution so that we might see at any moment the rapidity of the $H_2S$ stream. The water in this wash bottle was not darkened as was Professor Mason's and no mist was expelled; only a very little liquid paraffin was found in the front of the tube at the end of the operation. The $H_2S$ issued at a normal rate. At the end of the evolution of $H_2S$ some of the NaOH solution was blown back into the water in the wash bottle to absorb the $H_2S$ and convert it to $Na_2S$, after which the combined solutions were diluted to 1 liter and the analyses conducted as before. The results were 1322 cc. and 1300 cc. $H_2S$ gas.

The use of this material requires a deftness in technic which is perhaps not usually observed among students of qualitative analysis; but which we maintain is a most excellent thing to inculcate in the growing chemist.

We very much regret, of course, that Professor Mason should have felt it necessary to dub his article with the very objectionable caption which practically accuses my assignee of deceit. This seems to me to be entirely unjustified. Moreover, it may do a meritorious product great harm. However, we will hope that the users will judge for themselves and not be misled by Professor Mason's erroneous conclusions and unjust condemnation.

As to cost. We have always felt that in analytical chemistry it pays to relegate cost to the background. The total amount saved between the best and the worst is not worth considering. Therefore, we can always afford the best. The material is amply cheap enough to justify its use. Moreover, if Professor Mason or any one else prefers to mix his own material let him do so, so long as he does not offer it for sale.

In conclusion we cannot refrain from noting the remarkable concordance in the results of the tests made by Professor Mason. Heating two grams of a mixture (not a definite chemical individual) in such a manner as to distil out more or less of the reactants, as "yellow and brown mist," washing the $H_2S$ gas through water and collecting it over water (assumed saturated with $H_2S$) he obtains 121.1, 122.0, and 121.9 cc. $H_2S$, a variation from the highest to lowest of 0.74% of the mean result. In his second case he leads the evolved $H_2S$ into lead nitrate solution, dries and weighs the precipitated lead sulfide. In spite of the fact that lead sulfide is no longer a recognized gravimetric form and that when it was, it was deemed necessary to heat in hydrogen before weighing, he gets 1.2352, 1.2350, and 1.2356 grams lead sulfide. The percentage maximum variation in these results is 0.05%. These results are truly remarkable, especially as he "does not claim a high degree of precision."

Professor Mason states further that there are various products of the sort described on the market and that glass wool and mineral wool are used as vehicles. We know of no other products of this sort on the market and can state from actual trial that glass wool is not a suitable vehicle for the reactants.

If there are other products of this sort on the market I should be glad to have information concerning them, as they would probably be infringing a United States patent.

We can use other sources of hydrogen than paraffin (anthracene, for example) and may do so when we find one which in all respects we consider superior to paraffin.

306 KENT ROAD,
CYNWYD, PA. ABRAHAM HENWOOD

## "EUROPEAN AND AMERICAN METHODS IN EDUCATION"

A recent article of Mr. George W. Muhleman [THIS JOURNAL, **5**, 711–4, (June, 1928)] deals with observations by the author in some European universities, from which general conclusions about European methods of education are drawn. If Mr. Muhleman had made a more thorough investigation and had visited more schools, his conclusions would have been quite different.

After a stay of nine months in the United States, two months of which were spent at various universities and a longer period in contact with college men, the writer will try to indicate a few of the differences based on his observations of American and European (in particular, Dutch) universities.

The fundamental difference, which is immediately recognized, is the method of training of the students in the two continents prior to their entrance into college at the age of 18. In France, Germany, and Holland (for the other countries the writer has insufficient data) the pupils of the high schools have to study very hard and each year a large number, through failure to pass the school examinations, cannot be admitted to a higher class. This automatically reduces the number of those who attempt to enter college. The hours at school are supplemented by at least two or three hours of study at home each day, while study hours during the school period, a practice in many American high schools, do not exist. The number of subjects is not limited to five or six each year and the subjects are not chosen by the pupils; the class schedule contains at least twelve (in the last years even eighteen) different subjects. Typewriting, stenography, and similar subjects do not count for admission to a university and are only taught in special schools which do not train university aspirants. Accordingly, in most European countries, a student cannot enter

college without a thorough knowledge of mathematics, physics, chemistry, biology, history, geography, and one or more foreign languages (in Holland, these are English, French, and German). An American university has to develop first of all the general knowledge of the students; *i. e.*, it must in the earlier part of the college course complete their high-school training in English, French, or German, chemistry, physics, or mathematics. A European university has no such task, as the students it receives have acquired this general training in high school.

With these facts in mind, the conclusions of Mr. Muhleman will appear in another light. It is true that a European student in entering college has to set his goal more or less definitely while his American colleague may make his decision somewhat later. Specialization, however, is required in Europe only after the first examination (for candidate), which takes place during the third year. For example, a student who chooses chemistry for his profession will not have to decide, until he has studied for two or three years, which field (physical, organic, food chemistry, etc.) he will finally engage in. The time of examination is chosen by the student and it is not necessary to wait for a graduation day on which the whole class graduates, as in American colleges. A gifted student can pass his examination a few months earlier than the majority of his comrades, while a slow man may take a longer time. The knowledge required for the candidate's examination does not greatly differ from that necessary for the American B.Sc., B.A., or similar degrees.

The majority of the men who receive the degrees just mentioned leave the university to accept jobs. In Europe, however, only a few drop out after graduation; the greater number start a two or three years' course of more specialized work. In Holland, this second period ends with the degree of *doctorandus*, after which the students are allowed to start work for their dissertation, which consumes two or more years and leads to the doctor's degree. In this way, the total period of study in Holland is seven years or more, except for those who do not take the doctor's degree and who leave the university after the second examination. In Germany, the second examination leads to the doctor's degree. [See Paneth, THIS JOURNAL, **6**, 705–10 (June, 1928).] In other European countries, conditions are similar, and this will explain how Mr. Muhleman received the impression that study in Europe is more specialized. The fact is that more students remain at the university for research work after their first graduation, while for the majority of American students, the first graduation is the end of their college training.

Mr. Muhleman's observation regarding vacations is also worthy of comment. Though in Europe the students can study during their holidays and some of the less wealthy do, the majority enjoy themselves outdoors like their American colleagues. Opportunity to earn money does

not exist because of the prevalent condition of unemployment. It is difficult for a man of the New World to understand how much trouble most European students have in obtaining employment, especially in the way of unskilled labor as waiters, cooks, camp assistants, shop attendants, etc., by which many American students can earn their living. This is practically impossible in Europe.

I do not agree with Mr. Muhleman's judgment about the difference in the relations between professor and student in the two continents. In the first years, when the number of students is large, neither an American professor nor a European can find time to occupy himself personally with the individual students. However, the older students in Europe who are working for their dissertations have very close contact with their professors.

The remark that some classes of people are excluded from the universities concerns, fortunately, only some rare cases which one can find in nearly every country, even in the United States.

To summarize, the principal differences between American and European university systems lie in the divergence of the systems of preparation in high schools. American universities are handicapped by the lower level of training of the students when they enter. This obliges the American college to spend much time on subjects which in Europe are covered in high school. As it is easier to enter an American college, the number of students in the first years is larger than in Europe. However, fewer American students take the graduate courses. Raising the level of general intelligence is the task of an American university, but not of a European one.

The writer hopes that this letter will contribute to a better understanding of the educational systems of the New World and the Old.

JULIANALAAN 52 B,
OVERVEEN, HOLLAND

J. RINSE

* * * * * *

Dr. J. Rinse's comments on "European and American Methods in Education" contain nothing that in any way contradicts facts enumerated in my article published in the June issue of THIS JOURNAL. Dr. Rinse has a perfect right to express his opinions and the readers of the JOURNAL will no doubt be glad to have these supplementary statements relative to educational procedure in Holland universities.

I do not know whether Dr. Rinse intends to convey the idea that he is better able to report on American university methods after two months spent at various universities than I on European after ten months' residence at one of Europe's leading universities where I had abundant opportunity to meet and converse with university men from all over Europe and from all parts of the world.

He should know if he had observed carefully that no reputable American college or university accepts typewriting, stenography, and kindred subjects as entrance requirements as he implies in his letter. He should further know that no American college or university offers high-school courses in English, French, German, chemistry, physics, and mathematics as he also indicates in his letter.

Regarding vacations in Europe I have the statement from the editor of one of Europe's chemical journals, a man of profound learning and high standing in his profession, that vacations in Europe are a time for hard study. If European students do not all use the vacations in this way that is another question and one which I do not attempt to dispute. I am quite conversant with the labor situation in Europe, but I did not make employment or unemployment a part of my paper.

Dr. Rinse again takes positive issue with me when I compare the relationship between professor and student on the two continents. Here again he is taking issue not with me alone but with European professors. However, my own observation confirms me in the correctness of my statement.

I agree with Dr. Rinse that European students working for their dissertations do have close contact with their professors but I was not discussing graduate students. I had reference to the lower classmen. In this connection Dr. Rinse does not distinguish between the American university and the graduate school. He likewise gives one the impression that he knows nothing about the junior college and the senior college. He is ignorant of the fact that it is just as difficult to gain admission to the American graduate school as it is to gain admission to the European university, the two institutions being the same. When he states that fewer American students take the graduate courses he is attempting an impossible comparison, and also confessing his ignorance of the number of American students who are taking graduate work in our graduate schools. I found many supposedly well-informed men in Europe who, like Dr. Rinse, were woefully ignorant as to the amount and quality of work done in our American graduate schools. I also found many men in Europe who were unwilling to concede that it is possible for a country so young as the United States to contribute anything very much worthwhile in the way of original research.

Lastly, Dr. Rinse confesses that the task of the European universities is not to raise the general intelligence. My observations in Europe confirm that fact. The intolerable conditions in Europe are a sad commentary thereupon. European universities are long on theory but short on practice.

HAMLINE UNIVERSITY,
SAINT PAUL, MINNESOTA

GEO. W. MUHLEMAN

# Chemical Digest

## AVAILABLE ENERGY[1,2]

All knowledge that helps toward an understanding of the nature of the universe of which we are part is *useful*, for we need very much more of it than we now have, or shall have for centuries to come, to enable us to direct our energies toward *effective* living.

With this introductory explanation, Dr. Millikan proceeds to present, from the field of pure science, four recent developments not heretofore labeled useful, but which he hopes "may constitute an important and perpetually burning beacon to point out to mankind the way of progress, even of industrial progress," if correctly put together and interpreted.

1. *The discovery of the relation between mass and energy.*

In 1905 Einstein stated that as a consequence of his theory of relativity, the relation between mass and energy must be expressed in the following general equational form: $mc^2 = E$, where $m$ represents mass in grams, $c$ the velocity of light, $E$ energy in ergs.

The earlier experimental work of Kaufmann and the theoretical considerations of Lorentz, in addition to the more recent experiments of Michelson and Morley, have established the fact that at least no first order uncertainty is involved in this equation.

2. *The development of methods of making very exact atomic weight determinations.*

Aston of Cambridge University, England, has been primarily responsible for this development. From experimental considerations he has obtained (1927) a smooth curve representing a definite relation "between the atomic weights of the elements and the mass of the positive electron as it appears in the constitution of the nucleus of each particular atom." Basing his argument upon this curve and Einstein's equation, Dr. Millikan continues with a consideration of possible sources of available energy. He states:

> The first conclusion that we draw is that the process of radioactive disintegration with the ejection of an alpha particle is a process that can take place only in the case of a very few of the very heavy and very rare elements. For radioactivity is a heat-evolving—*i. e.*, an exothermic—process; otherwise it of course could not take place of its own accord, and Einstein's equation tells us that no energy-evolving or exothermic process can take place unless the total mass of all the constituents after the change is less than the total mass before the change—that an equivalent mass must always disappear if other forms of energy are to appear. But the relation of these masses

[1] *Ind. Eng, Chem.*, **20,** 1117–21 (Oct., 1928); *Science,* **68,** 279–84 (Sept. 28, 1928).

[2] Messel Medal address delivered by R. A. Millikan on September 4, 1928, at one of the sessions of the New York Meeting of the Society of Chemical Industry.

before and after any hypothetical change is just what is given by Aston's curve, which shows that no element of atomic weight under, say, about 100 can disintegrate with the ejection of an alpha particle and the evolution of energy. And yet more than 99 per cent of all matter consists of these atoms of atomic weight less than 100. Therefore, radioactivity with the ejection of alpha particles, even of very feeble energies, is not a general property of matter, as many of us have in the past thought it may be. Under the stimulus of the discovery of the enormous quantities of energy evolved in the disintegration of uranium and thorium, we have often imagined, and sometimes incautiously stated, that there might be similar amounts of available energy locked up in the common elements, releasable, perchance, by getting them to disintegrate as uranium and thorium spontaneously are doing. And engineers, physicists, and laymen alike have talked glibly about "utilizing this source of energy when the coal is gone." So-called humanists, on the other hand, advocates of a return to the "glories" of a prescientific age, have pictured the diabolical scientist tinkering heedlessly, like the bad, small boy, with these enormous stores of subatomic energy and some sad day touching off the fuse and blowing our comfortable little globe to smithereens.

However, this process of atomic disintegration is found completely wanting as a source of available energy, for we read:

If Einstein's equation and Aston's curve are even roughly correct, as I am sure they are, for Doctor Cameron and I have computed with their aid the maximum energy evolved in radioactive change and found it to check well with observation, then this supposition of an energy evolution through the disintegration of the common elements is from the one point of view a childish Utopian dream, and from the other a foolish bugaboo. For the great majority of the elements such as constitute the bulk of our world are in their state of maximum stability already. They have no energy to give up in the disintegrating process. They can only be broken apart by working upon them, or by supplying energy to them. Man can probably learn to disintegrate them, but he will always do it "by the sweat of his brow."

3. *The discovery of cosmic rays.*

The next possible source of energy suggested by the author is the process of atom-building. In addition to Einstein's equation and Aston's curve it is necessary, in this connection, to consider the recent experimental work on cosmic rays. Dr. Millikan and Dr. Cameron have found

. . . . these definite cosmic-ray bands or frequencies, of penetrating powers, or ray energies, respectively (equivalent to), 12, 50, and 100 times the maximum possible energies that are, or can be, obtained from any radioactive—that is, any disintegrating—process. The highest frequency band has so enormous a penetrating power that it passes through as much as 200 feet of water or 18 feet of lead before becoming completely absorbed, while 2 or 3 inches of lead absorb the hardest gamma rays. This discovery of a banded structure in cosmic rays shows definitely that these rays are not produced as are x-rays, by the impact upon the atoms of matter of electrons that have acquired large velocities by falling through powerful electrical fields, as we earlier suggested—the fields needed to produce frequencies as high as those of our highest observed cosmic rays are equivalent to 216,000,000 volts—but that they are rather produced by definite and continually recurring atomic transformations involving very much greater energy changes than any occurring in radioactive processes.

Taking Einstein's equation and Aston's curve as a guide, there are no possible atomic transformations capable of yielding rays of the enormous penetrating power

observed by us except those corresponding to the building up or creation of the abundant elements like helium, oxygen, silicon, and iron out of hydrogen, or possibly, in the case of the last two elements out of helium. The entire annihilation of hydrogen by the falling completely together of its positive and negative electrons has been suggested as an additional possibility, but it can be eliminated in this case for two excellent reasons. The first is that there is no place for such a radiation to occupy in the observed cosmic-ray curve; and the second is that this radiation, if it were present, would necessarily be homogeneous, and could not by any possibility exhibit the banded structure shown by the observed cosmic rays. So that here alone, by a process of exclusion, we have arrived at fairly definite evidence that *the observed cosmic rays are the signals broadcasted throughout the heavens of the births of the common elements out of positive and negative electrons.*

4. *The development of quantum-relativity mechanics.*

One of the outstanding contributors to this development has been an Englishman, Dirac, who has worked out a quantum-relativity mechanics formula, "giving the quantitative relation between absorption coefficient and frequency, or energy." Experimenting with the three prominent cosmic rays, Dr. Cameron and the author were able to measure fairly accurately their penetrating powers, or absorption coefficients. Dirac's formula enabled them

....to compute accurately from Einstein's equation and Aston's curve what should be the absorption coefficients, or the penetrating powers, of ether waves produced by the act of creation of the common elements out of the primordial positive and negative electrons.

After presenting facts to show that more than 95% of the universe is made up of the primordial positive and negative electrons, and of four elements built out of them—namely, helium, oxygen, silicon, and iron—the author returns to his discussion of sources of available energy.

Einstein's equation and Aston's curve then enabled Dr. Cameron and myself to compute the energies sent out in the ether signals arising from the creation in single isolated acts of helium, oxygen, silicon, and iron, and then Dirac's formula enabled us to compute the absorption coefficients of the corresponding cosmic rays.

The agreement of the theoretical and observed values for the absorption coefficients is sufficient proof to the investigators "that the observed cosmic rays are in fact the birth cries of the infant atoms of helium, oxygen, and silicon."

In answer to the question, "where are these atom-building processes going on?" we find:

It is "not at all in the stars," for high temperature and densities seem to be inimical at least to the process of the creation of the foregoing abundant elements out of the primordial positive and negative electrons. The building of the radioactive elements, which is an endothermic, or energy-absorbing, process may possibly be taking place in the stars, where surplus energy is available for it. We have no experimental evidence whatever on this point. But we have what we consider excellent experimental proof

that the foregoing endothermic processes that produce the cosmic rays do not take place in the stars at all. The full argument is given in the October issue of the *Physical Review*, but the fact that the sun, the great hot mass "just off our bows," has no influence whatever upon the intensity of the observed cosmic rays—for these come in just as strong at midnight as at noon—is enough to show that this particular star is not a source of cosmic rays. Since, however, these rays are coming into use all the time, and practically uniformly from all directions, Dr. Cameron and I can find no escape from the conclusion that these atom-building processes which give rise to the observed cosmic rays are favored by, and actually have their source in, the places in the universe where the temperatures and pressures are extreme in the opposite sense—that is, where they are close to absolute zero. In other words, we think that *the atom-building processes that give rise to the observed cosmic rays can take place only under the extreme conditions of temperature and pressure existing in interstellar, or intergalactic space.*

Combining this cosmic ray evidence with those conclusions already arrived at by astronomers like Eddington and Jeans, we have presented to us

. . . . the picture of a continuous atom-destroying process taking place under the extreme condition existing in the interiors of stars and an atom-creating process continually taking place under the equally extreme conditions of just the opposite sort existing in interstellar space.

If the common elements are being continuously formed in interstellar space, the question arises as to why the primordial positive and negative electrons have not long ago been used up. Dr. Cameron and the author reply that

. . . . out in the depths of space where we actually observe through the cosmic rays, helium, oxygen, and silicon being continually formed out of positive and negative electrons, there too these positive and negative electrons are also being continually replenished through the conversion back into them, under the conditions of zero temperature and densities existing there, of the radiation continually pouring out into space from the stars.

This assumption enables these investigators to regard the universe as in a *steady state*. The relative merits of this view as compared with the assumptions of Jeans on the one hand and of Stern, Tolman, and Zwicky on the other are discussed.

As for the future sources of energy available to man, we read:

1. The energy available to him through the disintegration of radioactive, or any other, atoms may perhaps be sufficient to keep the corner peanut and pop-corn man going on a few street corners in our larger towns for a long time yet to come, but that is all.

2. The energy available to him through the building-up of the common elements out of the enormous quantities of hydrogen existing in the waters of the earth would be practically unlimited, provided such atom-building processes could be made to take place on the earth. But the indications of the cosmic rays are that these atom-building processes can take place only under the conditions of temperature and pressure existing in interstellar space. Hence there is not even a remote likelihood that man can ever

tap this source of energy at all. The hydrogen of the oceans is not likely ever to be converted by man into helium, oxygen, silicon, or iron.

3. The energy supplied to man in the past has been obtained wholly from the sun, and a billion years hence he will still, I think, be supplying all his needs for light, and warmth and power entirely from the same source.

4. When the matter of the sun has all been stoked into his furnaces and they are gone completely out, another sun will probably have been formed, so that on this earth or on some other earth, it matters not which, a few billion years hence, the development of man may still be going on. M. W. G.

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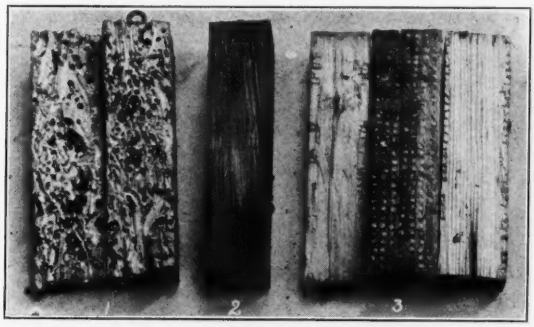
## BY-PRODUCTS OF CHEMICAL WARFARE[1,2]

The value of by-products in the industrial world is well recognized but do we fully appreciate the peacetime importance of the research by-products of the Chemical Warfare Service at Edgewood Arsenal? We all know that its chief military purpose is to study means of protecting our Army and




MARINE PILINGS SHOWING PROTECTION AFFORDED BY TOXIC IMPREGNANTS

Left: untreated control piece. (Note damage done by Limnoria.) Other pieces treated with toxic impregnants.

country against future warfare, but do we realize the civic possibilities of the organization's study of toxic materials? Apropos of this subject we quote from Major-General Amos A. Fries, Chief, Chemical Warfare Service, U. S. Army.

Any peacetime problem involving the use of, or protection against, poisonous materials is one which this organization is preëminently qualified to solve. As many such problems are closely related to chemical warfare research, their solution flows directly from the research activities of this service.

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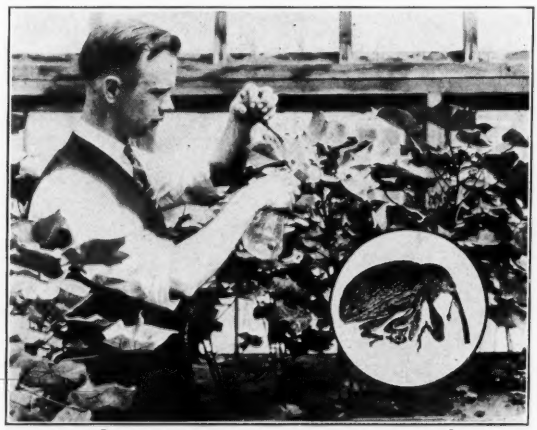
[1] *Ind. Eng. Chem.*, **20**, 1079–84 (October, 1928).

[2] The cuts accompanying this article are reproduced through the courtesy of *Industrial and Engineering Chemistry.*

Continuing, we find some of the commercially valuable peacetime achievements of the Chemical Warfare Service described in detail.

Considerable progress has been made in the study of the *protection of marine piling*. The estimated value of the annual destruction of docks and other water-front structures caused by marine borers is placed at one million dollars. Surely these figures warranted expert investigation of this problem, and we find that for the last several years the Chemical Warfare Service has been carrying out systematic experiments regarding the relative effectiveness of numerous toxic substances on the various types of marine borers. The following conclusions have been drawn from the work:

1. About fifteen compounds show specific toxicity against marine borers of from twenty-five to fifty times that of creosote.



TESTING NEW POISONS ON THE BOLL WEEVIL. INSERT: BOLL WEEVIL (MAGNIFIED)

2. Better protection for piling than is afforded by creosote alone may be obtained at a very slightly increased cost by the addition of a specific toxic to the creosote.

3. At least equal protection to that afforded by creosote may be obtained at less cost, by the addition of a specific toxic to fuel oil or some other cheap vehicle.

4. Final selection of the best all-rough materials for use depends upon the results of the long-time test pieces now installed.

5. The use of any of these materials will not involve any change in the present commercial methods of impregnation.

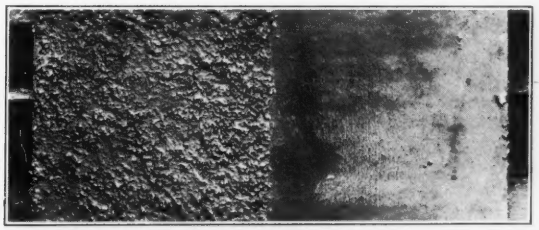
6. Little or no increased hazard, either in the impregnation process or in the installation of the piling, results from the use of any of the compounds now being tried in long-time service.

*Methods of controlling the ravages of the boll weevil*, whose annual destruction is estimated at millions of dollars, constitute a second problem

under investigation by the Chemical Warfare Service. As a result of preliminary laboratory tests and subsequent large-scale field tests, covering a period of three years, during which time comparative toxicity tests of more than 1000 poisons and poisonous mixtures were run, we read that:

Two materials stand out as commercially possible boll weevil poisons in comparison with the standard commercial calcium arsenate. One of these is a special calcium arsenate containing about 20% arsenic, as against the 40% arsenic content of ordinary commercial calcium arsenate. The other material, a sodium fluosilicate, can be obtained as a by-product in the manufacture of acid phosphate. The Chemical Warfare Service has taken these poisons from the laboratory stage and developed them to a point of real economic importance in the field.

The necessities involved in devising *ship-bottom paints* to combat the



SHIP-BOTTOM PLATE SHOWING EFFECT OF TOXIC PAINT IN PREVENTING MARINE GROWTHS
Left: ordinary paint. Right: toxic paint.

accumulation of marine organisms on the hulls of ships are stated as follows:

1. To develop a paint that will remain permanently on ship bottoms.
2. To include in such a paint a material that is sufficiently toxic to kill or prevent the attachment of the marine organisms, and to maintain this degree of toxicity for the life of the paint. Practically all these organisms begin their life history as free-swimmers and after attaching themselves grow and mature, obtaining food from the surrounding water. It is, therefore, necessary for the poison to act only during the period of attachment.
3. To develop an auxiliary paint (applied under the anti-fouling paint) to protect the steel plating from the corrosive action of the sea water, and to prevent electrolytic action between the plating and metallic constituents present in the toxics.
4. To develop these paints from domestic material, and to keep the cost of manufacture and application as low as is consistent with proper functioning.

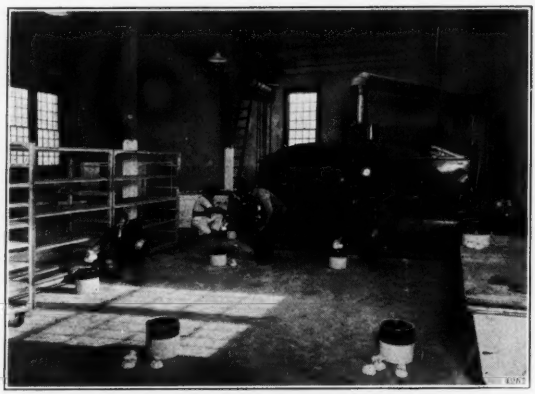
As to the progress made in this investigation, we read:

The Chemical Warfare Service has been coöperating with the Navy Department in a study of this problem, working on two different types of paint. The first is the so-called hot-plastic paint, which is applied in a melted condition, and solidifies on cooling. The other is the varnish type, which is applied cold, and dries by evaporation of a solvent.

We are all aware of the government regulation requiring fumigation certificates of all ships arriving at the U. S. Quarantine from a foreign country. Major Fries' article points out the many disadvantages of the widely used fumigant, hydrocyanic acid. To replace it:

> The Chemical Warfare Service, in coöperation with the Public Health Service, developed a method of fumigation whereby cyanogen chloride, an intense war tear gas, is generated along with the hydrocyanic acid. This compound is also highly poisonous, so that the mixture is almost as efficient as the hydrocyanic acid alone and, in addition, gives instant warning of its presence, even in sublethal concentrations. The fumigating mixture is generated by adding a mixture of sodium cyanide and sodium chlorate to dilute hydrochloric acid. This method has been adopted by the Public Health Service and is now in general use by it.

As a necessary auxiliary investigation a special mask, supplied with



METHOD OF FUMIGATING AN ARMY BAKERY WITH LATEST TYPE GAS WHICH WARNS AGAINST DANGEROUS CONCENTRATIONS
Personnel protected by masks.

effective absorbents for the cyanogen chloride and hydrocyanic acids, to be used by the workmen engaged in fumigation, was developed.

The rôle of this Service in developing masks for protection against ammonia (chiefly needed in the handling of ammonia cylinders, and in the operation of ice plants), and in using tear gas (chloroacetophenone) in small hand-thrown bombs or grenades for controlling mobs is briefly described.

An additional problem of obvious industrial application, which has been studied extensively by the Chemical Warfare research staff, is that of *protection against industrial poisons*. From the description presented of the details involved in devising practical means of complete temporary protection against carbon monoxide and carbon dioxide, we

realize the scope and the possibilities of the peacetime activities of the Chemical Warfare Service.

Major Fries concludes his illuminating article with the following comments:

It should be pointed out that the majority of the most valuable contributions of the Chemical Warfare Service to industry have been entirely incidental to its regular military researches. Others have been undertaken at the request of various other government bureaus because of special talent and equipment which this service has for investigations in the field of poisonous materials and protection therefrom. In all cases, once a solution of the problem is reached and a new device is designed or produced to solve a given difficulty, the Chemical Warfare Service does not attempt quantity production or supply commercial needs for this device. It merely makes a sufficient number for governmental use and publishes its findings and results so that commercial firms may engage in the manufacture thereof. The Chemical Warfare Service was provisionally established during the summer of 1918 and inherited the chemical warfare research and development work theretofore carried on by other agencies of the Government, notably the Bureau of Mines. Hence, the initial steps of many of the foregoing achievements were taken by these other agencies and later developed by the Chemical Warfare Service. Since its permanent establishment in 1920 the appropriations for the support of the Chemical Warfare Service have averaged only 0.37 to 1 per cent of the appropriation for the Army. Of this sum approximately one-third has been devoted to research and development. It is believed that the contributions of the Chemical Warfare Service to industry alone have more than amply justified the sums devoted to research, to say nothing of the tremendous progress made in the protection of our Army and Nation against enemy chemical warfare in any future emergency.

M. W. G.

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## CRAFTSMANSHIP AND SCIENCE[1,2]

After a few introductory remarks, Sir William Bragg defines craftsmanship to mean "the skill which is exercised in the production of whatever is wanted for human welfare." He then elaborates this definition, describing the various activities of the inhabitants of an isolated island, forcibly bringing out the point that if the islanders are to live at all, the products of craftsmanship are a necessity, and that this craftsmanship also determines their success.

After considering briefly the older forms of craftsmanship, the author continues:

It is indeed well known to you all that the craftsmanship of a people is an expression of the best of its very self. It is to the underlying reason that I would draw your attention now. The mind of a nation is so expressed because its craftsmanship, interpreted in its widest sense, represents its efforts to live. Under this strong compulsion the

[1] *Science*, **68**, 213–23 (Sept. 7, 1928).

[2] Presidential address of Sir William Bragg before the British Association for the Advancement of Science, Glasgow, Scotland, Sept., 1928.

nation produces results which range from pots to poetry, and all its products are stamped alike. That which we do ourselves is as representative as a Greek vase or a Roman aqueduct or a suit of armor from Milan. The craftsmanship of a nation is its very life. Even if we consider it only in relation to the production of material things, the state of a nation's craftsmanship is an index of its health.

In explanation of the change which has taken place in craftsmanship since these earlier civilizations, we read:

I would ask you to consider the nature of the change. The elements of craftsmanship in its original form center round the individual. In his brain is the knowledge and imagination, in his hands is the skill, and round about him lie the materials and the tools of his craft. But as the years go by it becomes impossible that all the knowledge and all the technical skill should be found in one person, and all the tools be owned by him. The craftsman becomes an association of men, a great manufacturing firm, even, we might say, a nation, if all the members of the nation contribute through government intervention and control to the maintenance of some industry. Many hands, working in an alliance which is often unconscious, are employed in bringing a product to its finished form. It is a long step from the simple workshop of the old single-handed craftsman to the vast complex factory of modern industry.

The cause for the development of this new kind of modern craftsmanship is, according to Sir William Bragg:

....nothing more nor less than the urgent wish of the individual to better his own condition: and in his disinterested moods, the condition of his neighbors.

In defense of this attitude he says:

Quite apart from all considerations as to whether the new is better or worse than the old, more beautiful or less beautiful, whether it calls out the best in man as well as the older ways, or whether it fails to do so, apart from all comparisons of this kind stands the fact that the change is due to natural impulses which will not be gainsaid. The results have to be accepted. We cannot put the clock back. We cannot, let us say, wipe away the great steel works of the world and replace them by thousands of individuals each with his single anvil and single hammer. We cannot replace the great ships of Glasgow by a multitude of little sailing boats. The plain truth is that modern craftsmanship with all its noise and ugliness is giving food and clothing, warmth and interest to millions who otherwise must die. It is ungrateful to find fault except with sympathy. Let us try in all possible ways to mend its offenses and soften its hardships, but in all honesty let us recognize that we live on modern craftsmanship in its modern form. We are each and every one of us responsible for the present conditions as long as we insist on spending money to the best advantage.

Having thus defined craftsmanship, the author discusses its relationship to science. Several examples are cited which illustrate how

Craftsmanship in its urgent need has called upon scientific knowledge for aid, and the mighty growth is due to the response. Indeed, it is not only craftsmanship that has grown, but science itself.

Commenting upon this the author continues:

If you hinder the growth of science in any way you hinder the growth of craftsmanship. Now it is an important fact that science advances over a wide front, and

the various branches of it move on together, not absolutely keeping step with each other, but preserving a general line. It has been suggested that science might refrain from development in some directions or, even as our good friend the Bishop of Ripon said at Leeds last year, we might proclaim a ten years' holiday. But you cannot prevent interested men from making inquiry. You cannot prevent the growth of knowledge, you cannot even make a selection of those points of advance which will lead to certain select classes of results. No one knows what is over the hill. The vanguard moves on without any thought of what is before it. That is why, if the march of science is to be conducted in an effective and orderly way, were it only for the purposes of industry, there must always be a certain number of laboratories or parts of laboratories where scientific research has no immediate thought of possible applications.

In considering further the closeness of the connection existing between craftsmanship and science, several of the modern industries (electrical, motor, airplane, chemical industries in general) are described in enough detail to illustrate the fact that most modern industries have been founded on and are progressing due to scientific research.

The general connection between science and that condition in industry which is known as mass production is pointed out, the author summing up his comments as follows:

The relation of science to mass production is therefore both that of builder and that of destroyer. Mass productions are temporary lulls in the movement of imagination and knowledge. Much skill and thought and care may be required to arrange for one of those quiet and profitable times; the machine is set going and for a while goes by itself. But new applications of scientific knowledge, new ideas, new processes, new machines must always be in preparation. In the parks the gardeners are always nursing fresh plants to take the place of the old, and preparing them for their useful time of flowering. And so we see the meanings of the various research organizations which have been set up in the basic industries, such as the Fuel Research Board, the Cotton, the Woolen and the Silk Research Associations, the research laboratories of the steel masters at Sheffield. Much of our hope for the future is built upon their work.

A nation's success depends upon its ability to provide for its people, and this in turn depends upon the continual improvement in the processes of its craftsmanship. The absorption and adaptation of scientific discovery, upon which processes this improvement seems to depend, leads the author to the discussion of a second aspect of the relations between craftsmanship and science.

We here come to a point which must be emphasized with all possible vigor, because its importance is not always realized. Scientific knowledge and experience, if it is to be of full service, must be in direct practical contact with the problem that is to be solved. This must be clear to every one of us from actual experience. If you have expert knowledge on any subject and your advice is asked, your first instinct is, as you all know, to ask to be allowed to see for yourself. It is only when all the circumstances are clear to you in their relation to the difficulty that the solution is likely to suggest itself. And it may take much watching and patient observation before you are successful. It is the combination of actual experience with scientific knowledge that is essential.

By describing in some detail the problem of locating enemy guns, Sir William Bragg drives home the fundamental principle outlined just above. He then proceeds to discuss this situation from a broader viewpoint.

There is a public estimation of the value of any calling which affects the numbers and the quality of those who respond.

I doubt if there is in the first place sufficient appreciation of the interests and rewards in the life of a student of industrial research. The pioneers have suffered unnecessary restrictions and discouragements, but their followers will be in better case. Surely it does not need much imagination to realize the splendid side of such work! The succession of fresh difficulties to be overcome, and of new and interesting views into the nature of things and ways of the world: the unforeseen value of results, sometimes an immediate prize, sometimes the clearing of an obstacle in a manufacturing process, never less than the discovery of facts which may some day be of use: the personal association with a living enterprise and with the human spirit behind it. And when it is realized that this kind of work is wanted badly, that it is really serviceable to the community, that there is opportunity for devotion, that it is in touch at once with human needs and with the furthest stretches of thought and imagination, it surely takes on to us the final touch of nobility.

We must remember also that the road of the student of science is still none too clear. The very methods of teaching science are a constant subject of discussion. I will say no more now than this: that the best methods must take time to elaborate, and cannot be expected to have arrived at their final form. The difficulty is increased by the fact that science itself grows rapidly, and the extent of its application is only now revealing itself. That the knowledge of the immensity of nature and the study of the natural laws have an educative value is well recognized. That science can be used as an educational drill is also known and made use of. But there still remains the human side: the continuous effect of the growth of knowledge upon thought and enterprise, the realization of the immense part that science is playing in modern life and is likely to go on playing. Education by scientific instruction is still apt to lack the comprehension of the human side, without which the classroom is a dull place.

There are even some who think that science is inhuman. They speak or write as if students of modern science would destroy reverence and faith. I do not know how that can be said of the student who stands daily in the presence of what seems to him to be infinite. Let us look at this point a little more closely.

The growth of knowledge never makes an old craft seem poor and negligible. On the contrary it often happens that under new light it grows in our interest and respect. Science lives on experiment: and if a tool or a process has gradually taken shape from the experience of centuries, science seizes on the results as those of an experiment of special value. She is not so foolish as to throw away that in which the slowly gathered wisdom of ages is stored. In this she is a conservative of conservatives.

How, then, are we to put our scientific knowledge into the position where it is really effective? The reader's attention is called to a most interesting and important movement which is attaining notable magnitude at the present time.

A new class of worker is growing up among us, consisting of the men engaged in research associations and industrial research laboratories throughout the country. We must place a high value on their services, for they are actually and personally bringing back with them into craftsmanship the scientific knowledge which is one of

its essentials. They bring the interest and the outlook of scientific inquiry into touch with both employer and employed, and I cannot but think that they may be to some extent the flux that will make them run together. For they can speak with the employer as men also trained in university and college, exchanging thought with ease and accuracy. And, at the same time, they are fellow workers with those in the shops and can bring back there some of the interest and enthusiasm which springs from the understanding of purposes and methods. It is to be remembered always that personal contact has, on the whole, thanks to the better qualities in human nature, a marvelous effect in smoothing out differences. I do not think it is unduly optimistic to welcome the growth of this new type of industrial worker because it can, being in personal intercourse with both capital and labor, supply to each a new outlook on their whole enterprise, especially as that outlook is naturally illuminating and suggestive. For, after all, this is but going back to first conditions. The primitive craftsman has been replaced by separate persons or groups of persons who have slipped away from each other almost without our realizing the fact. In the most recent times the separation has become more obvious and more dangerous, and that is why in so many directions efforts are being made to stem it. Can it be good that the workman has a part demanding little intelligence, merely the capacity to repeat? Can it be expedient that mere manipulation should be left in the shop, while design and imagination have gone into the drawing office and shut the door behind them? Can it be right that the factory directorate should not be in immediate contact with the vast body of scientific knowledge?

The present number of industrial research workers is relatively small; it seems likely to increase, however, in proportion to the extent to which the province of science is better understood. The better understanding I think of as manifested in the first place in industry itself. I am sure that here it is happily on the increase.

What is true of a tool or process is true also of those formulas in which growing science has tried to describe her discoveries. A new discovery seems at first sight to make an old hypothesis or definition become obsolete. The words cannot be stretched to cover a wider meaning. By no means, however, is that which is old to be thrown away; it has been the best possible attempt to express what was understood at the time when it was formed. The new is to be preferred for its better ability to contain the results of a wider experience. But in its time it will also be put aside. It is by a series of successive steps that we approach the truth: each step reached with the help of that which preceded it.

Nothing in the progress of science, and more particularly of modern science, is so impressive as the growing appreciation of the immensity of what awaits discovery, and the contrasted feebleness of our ability to put into words even so much as we already dimly apprehend.

When we look back over the two centuries or so during which scientific men have tried systematically to solve the riddle of light, or even go further back to the surmisings of philosophers of still older time, we see that every conscientious attempt has made some approach to the goal. The theories of one time are supplanted by those of a succeeding time, and those again yield to something more like the first. But it is no idle series of changes, no vagaries of whimsical fashion; it is growth. The older never becomes invalid, and the new respects the old because that is the case.

Surely it is the same in regard to less material affairs. The scientific worker is the last man in the world to throw away hastily an old faith or convention or to think that discovery must bring contempt on tradition.

There is a curious parallelism here to a relation between science and industry of which I have already spoken. Just as any particular case of mass production can be

regarded as a temporary condition which the growth of knowledge brings about, and in the end supersedes, so also it may be said of any law or rule or convention or definition that knowledge is both the parent and eventually the destroyer. Time devours his own children. Even if a statement retains its outward form, its contents change with the meanings attached to its terms: and change moreover in different directions when used by different people, so that constant redefinition is necessary. How much more is this the case when the contents themselves have to be added to. The distinction between truth itself and attempts to embody it in words is so constantly forced upon the student of science as to give his statements of all matters a characteristic form and expression. And this is, I think, one of the reasons why men are often needlessly alarmed by the new announcements of science and think they are subversive of that which has been proved by time.

To this consideration I may add yet one more, which may be illustrated by the same analogy. Scientific research in the laboratory is based on simple relations between cause and effect in the natural world. These have at times been adopted, many of us would say wrongly, as the main principle of a mechanistic theory of the universe. That relation holds in our experimental work: and as long as it does so we avail ourselves of it, necessarily and with right. But just as in the case of research into the properties of radiation we use a corpuscular theory or a wave theory according to the needs of the moment, the two theories being actually incompatible to our minds in their present development, so the use of a mechanistic theory in the laboratory does not imply that it represents all that the human mind can use or grasp on other occasions, in present or in future times.

The proper employment of scientific research is so necessary to our welfare that we cannot afford to allow misconceptions to hinder it: and the worst of all are those which would suppose it to contradict the highest aims. Science, as a young friend said to me not long ago, is not setting forth to destroy the soul of the nation, but to keep body and soul together.

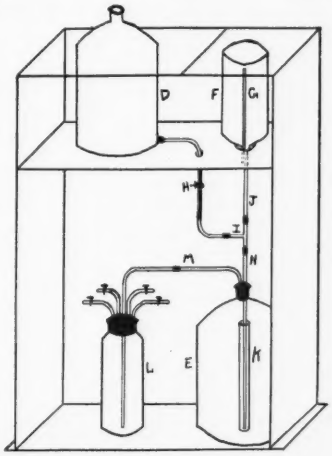
And some perhaps might say that in considering science in relation to craftsmanship I am pressing the less noble view, that I am not considering knowledge as its own end. It is said that uselessness in science is a virtue. The accusation is a little obscure because it may justly be said that knowledge is never useless. If I have thought of science in relation to craftsmanship, it is because I have tried to set out the vast importance of what craftsmanship means and stands for. I have not forgotten that there are other aspects of the inquiry into the truths of nature. Indeed, I could not carry out the lesser task without considering the whole meaning of science. And no clear line can be drawn between pure science and applied science: they are but two stages of development, two phases which melt into one another, and either loses virtue if dissociated from the other. The dual relation is common to many human activities and has been expressed in many ways. Long ago it was said in terms which in their comprehensiveness include all the aspirations of the searcher after knowledge: "Thou shalt love the Lord thy God with all thy heart and with all thy soul and with all thy strength" and "Thou shalt love thy neighbor as thyself." In the old story every listener, from whatever country he came, Parthians and Medes, Cretans and Arabians, heard the message in his own tongue. A great saying speaks to every man in the language which he understands. To the student of science the words mean that he is to put his whole heart into his work, believing that in some way which he cannot fully comprehend it is all worth while, and that every straining to understand his surroundings is right and good: and, further, that in that way he can learn to be of use to his fellow men.

M. W. G.

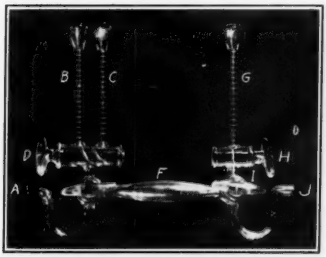
# ABSTRACTS

## TEACHING METHODS, AIDS, APPARATUS, AND SUGGESTIONS

**An Improved Gas Generator.** V. T. JACKSON. *Ind. Eng. Chem.*, **20,** 771 (July, 1928).—The gas generator herein described may be used for hydrogen sulfide, carbon dioxide, or hydrogen. Full directions for making stand and assembling the apparatus are included. Desirable features are: one filling with ferrous sulfide will last for at least a year; there is no waste in drawing off the spent acid; precipitation under pressure is easily accomplished. In explanation of cut reproduced: *D* and *E*—8-liter aspirator bottles; *F*—2-liter acid bottle, fitted with a 2-hole rubber stopper; *L*—wide-mouth bottle with minimum capacity of 1 liter; *G*—glass tubing, 3 mm. inside diameter; *J*—glass tubing, 8–10 mm. inside diameter; *I*—T-tube; *N*—glass tubing, 8–10 mm. inside diameter; *K*—glass tubing, 20 mm. inside diameter; *M*—glass tubing, 8–10 mm. inside diameter; *H*—Hoffman screw clamp. M. W. G.



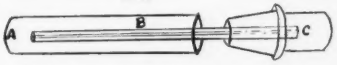

**Apparatus for the Micro-Determination of Dissolved Oxygen.** T. G. THOMPSON AND R. C. MILLER. *Ind. Eng. Chem.*, **20,** 774 (July, 1928).—The all-glass apparatus shown in the accompanying illustration was devised for determining dissolved oxygen in water when only small quantities (5–10 cc.) of the sample are available. In explanation of the illustration: *A,F,J*—reservoir to contain sample to be analyzed, capacity 5–10 cc.; *E,I*—three-way stopcocks; *D,H*—stopcocks; *B,C, G*—reservoirs for reagents.




Methods for sampling, treating sample with reagents (the usual reagents, manganese sulfate solution, sulfuric acid, and potassium hydroxide-potassium iodide solution, for Winkler's method are used), and titrating are given in detail.

"The procedure given is regarded as an improvement on that suggested by Lund (*Proc. Soc. Exptl. Biol. Med.*, **19,** 63 (1921)), in providing greater convenience, more accurate control in the addition of smaller amounts of reagents, and complete protection of the sample from any possible contamination with the air." M. W. G.

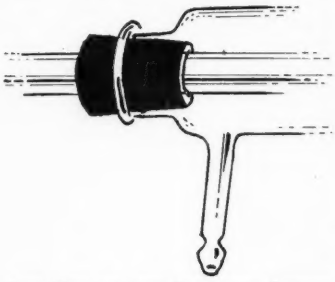
**A Rapid Method for Determining Colorimetrically the pH of Small Amounts of Solutions.** OSCAR W. RICHARDS. *Science,* **68,** 185 (Aug. 24, 1928).—A capillary pipet, test tube, and combined rubber bulb and stopper assembly is described to be used in obtaining uniform samples for color comparisons following a method similar to that of Felton. It is recommended that the spotting plates be given a light coating of high-grade vaseline to make the drops stand up. G. H. W.




*A*–TEST TUBE; *B*–CAPILLARY; *C*–BULB AND STOPPER

**Simple Apparatus for Use in Colorimetric Titration.** EDWIN B. POWERS. *Ecology,* **9,** 364 (1928); *C. A.*, **22,** 3319 (Sept. 20, 1928).—The apparatus consists of a 250-cc. Erlenmeyer flask, to the neck of which is sealed a test tube, and to the bottom of which is sealed a neck adapted to take a no. 10 stopper. The liquid being titrated is compared with color standards while in the test-tube portion of the apparatus, and titrations may be carried out under gas pressure. M. W. G.

**An Improvement in Condensers.** *Laboratory*, **1**, 13 (1928).—The Liebig condenser, when made of glass, has been made with the jacket drawn down at the ends, with rubber tubing connecting it to the inner condensing tube, or it has been made with the jacket and condenser permanently sealed together.



ONE END OF THE IMPROVED LIEBIG CONDENSER

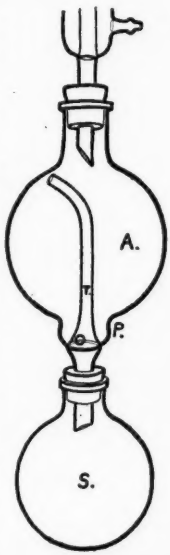
Condensers with metal jackets have employed rubber stoppers to seal the ends and hold the inner tube, but for some reason (probably inheritance), glass condensers were not made this way.

The glass Liebig condenser, *rubber stoppered*, can now be obtained and it has some advantages. There is quite a saving in breakage, because the weak part, where the glass came in contact with glass, is eliminated. Condensing tubes are more easily replaced. M. W. G.

**Improved Laboratory Condenser.** ED. S. WEST. *Ind. Eng. Chem.*, **20**, 737 (July, 1928).—"The accompanying illustration shows a condenser which has been found strikingly superior to the old Liebig type for general laboratory and research use. The condenser is easily made from two pieces of Pyrex glass tubing so chosen that the smaller fits into the larger, leaving a space of 1 to 1.5 mm. between the tubes. The larger tube, which is to serve as the water jacket, is fitted with side tubes for the water inlet and outlet. The smaller tube, which is the condensing tube, is cut the same length as the larger jacket tube, slipped into it, and the edges of the outer and inner tubes are sealed to each other at the end. An adapter is then sealed to one end of the condenser as shown. The outer tube should be made of medium or heavy Pyrex tubing and the condenser tube of the lighter grade. A convenient laboratory size condenser has an inner tube of 7 to 9 mm. inside diameter, a total outside diameter of 12 to 15 mm., a water column between inlet and outlet tubes of 300 mm. length, and an over-all length of about 550 mm.

AN IMPROVED LABORATORY CONDENSER

"Such a condenser is small, compact, and easy to manipulate, requiring only buret clamps for support and in many cases no clamp support at all. It is sturdy and much less subject to breakage than the older types, because the heavy outer jacket tube protects the inner condensing tube all the way to the end. There are no rubber connections to leak or replace. The greatest advantage is that it is much more efficient than the old Liebig type. The same quantity of water passes through the condenser as in case of the Liebig, but owing to the narrow space between the condensing tube and the outer jacket the circulation is much faster and the cooling layers of water next to the condensing tube are changed many times more rapidly than in the case of the Liebig condenser." M. W. G.




**A Large-Capacity Laboratory Extractor.** F. E. HOLMES. *Ind. Eng. Chem.*, **20**, 888 (Sept., 1928).—"The extraction apparatus illustrated was designed to meet a need for apparatus to prepare fat-free constituents for rations for experimental animals in somewhat larger amounts than could be done with the Soxhlet extractor. It is more easily assembled and of much more rugged construction than the large extractors with which we were familiar. A further advantage is that the tube which delivers the vaporized solvent is kept warm in the center of the extraction flask; consequently, less solvent condenses and runs back. When alcohol or benzene is the solvent satisfactory results can be obtained by immersing the lower flask to the neck in a water-bath

kept vigorously boiling by steam, thus avoiding the possibility of the solvent catching fire, and minimizing the amount of attention required in carrying out the extraction.

"The small bulb, *P*, is packed with cotton to act as a filter and the material to be extracted is placed above it in *A*. The flask is then connected to *S* containing the solvent, and to a reflux condenser. The vaporized solvent is delivered through *T*. The condensed solvent returns through a small hole in *T* near the bottom of *P*.

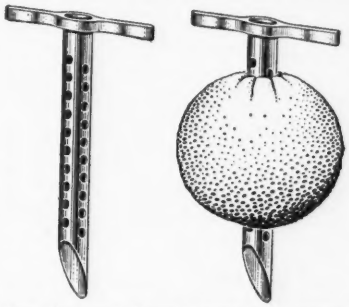
"Two of the above extractors were blown using a 1-liter Pyrex flask for one and a 2-liter flask for the other. Pyrex tubing of about 11 mm. diameter inside below the seal and 5 to 7 mm. diameter above was used for *T*. Two pieces of Pyrex tubing of the proper size were fused end to end and the joint blown out a little beyond the diameter of the larger one. The small hole for the return of liquid solvent was blown just above this in the small tube. A bulb was blown to form *P* on the bottom of the flask and an opening blown out in the end. The tube was then fused in place in this opening."

M. W. G.

**The Cork Borer in a New Rôle.** *Laboratory*, **1**, 40 (1928).—"A little ingenuity has redressed a popular laboratory appliance and put it into society, under the name of "Fruit Tap." It is a thin metal tube with handle and a tapered end and has staggered holes as shown in the illustration. This is the laboratory technician's old friend, the cork borer, with the addition of the holes and tapered end.

"The Fruit Tap is inserted through the center of an orange or lemon and acts as a drainage tube for the juice when the fruit is squeezed. The holes are too small to pass the seeds or large particles of pulp, hence the juice thus extracted is well suited for the purpose for which it is usually employed.

"It can be used in the laboratory for obtaining samples of citrus fruits, in the kitchen for extracting fruit juices for cooking, and in the pantry or other rooms where solutions containing fruit juices are prepared.



THE EVOLVED CORK BORER IN ACTION

"We tried it in one of the above-mentioned rooms and although it is not going to revolutionize the technic of a popular social custom, it really works." M. W. G.

**The Metallurscope.** *Laboratory*, **1**, 12–3 (1928).—This new instrument is portable and can be used both for observing and photographing micro-structure of metals (such as castings, plates, forgings, sheet metal, cylindrical objects such as tubing, axles, wire rope, etc.).

A large field can be examined under low magnification or a small field can be examined under high magnification. Small polished specimens or large surfaces of various contours can be examined. Magnifications from 28× to 1500× can be had in visual examinations and magnifications from 1× to 2400× can be obtained when making photographs. M. W. G.

**The Analytical Balance.** *Laboratory*, **1**, 61–3 (1928).—The adjustment of the modern analytical balance is briefly described from an accompanying diagram. Directions given for cleaning the balance are easily understood. The use of drying agents to keep a balance dry is discouraged, and the proper location of the balance stressed. A photograph of the original Cavendish analytical balance, which is at present in the museum of The Royal Institution in London, accompanies article. M. W. G.

**Analytical Filtration Accelerated.** *Laboratory*, **1**, 4–7 (1928).—"There has always been a demand by chemists for filter papers that will filter rapidly and retain all types of precipitates. Unfortunately, both the speed and retentivity of a filter paper are controlled by the density, or porosity, of the paper. Rapid filtering requires an open texture and ability to retain requires a close texture; therefore, a paper which will filter rapidly and at the same time have high retentivity, simply cannot be made. For this reason, filter papers should be described by specific statements as to speed of filtration and retentivity, with statements as to the type of precipitates each paper will hold.

"The combination of greater filtering speed and more complete retentivity has been made possible by devising an accelerator which is added to the solution to be filtered. This accelerator is made of pure paper fiber; size 30 × 16 mm. × 1.5 mm. thick, with a total weight of about 0.27 gram. The fiber has been treated with hydrochloric and

hydrofluoric acids and washed with distilled water. The average weight of ash of an accelerator is 0.00018 gram.

"The accelerator is dropped into the solution to be filtered and then stirred into the solution with a glass stirring rod. The disintegrated accelerator acts as a mechanical suspensoid and the particles of the precipitate adhere to it. When the solution is poured into the funnel containing the filter paper, the major portion of the particles of the precipitate is held by the disintegrated accelerator and prevented from getting into the pores of the paper and clogging."

Data on tests (both time and retentivity) to show the effectiveness of the accelerators are given. Observations made include:

1. That the filtration of any type of precipitate, using any grade of filter paper, is made more quickly when the accelerator is employed.
2. That with any grade of filter paper, more of the precipitate is caught in one passage when the accelerator is used.
3. With the aid of the accelerator, papers which filter more rapidly can be employed, because the retentivity is increased. This, together with the additional speed provided by the accelerator, makes the filtration even more rapid.
4. The retention of exceedingly fine precipitates (those difficult to hold with any paper) is facilitated by the use of the accelerator and, at the same time, the filtration is made more quickly.
5. The number of passages of the solution through the paper can be reduced when the accelerator is employed. In the usual commercial analysis, one passage of the solution through the paper is sufficient when the accelerator is used.
6. In connection with the laboratory work in making the tests, it was found that one accelerator is sufficient for 250 cc. of solution when the amount of a fine precipitate did not exceed 1 gram. The accelerator is more effective with a flocculent precipitate than with a fine precipitate but it was found that one accelerator was sufficient for the precipitate obtained in the usual analysis. For the unusual filtrations where larger quantities of precipitates are to be filtered, the use of additional accelerators is recommended.
7. It was also found that it was advantageous to add the accelerator when the highest temperature was reached during precipitation. If still quicker disintegration of the accelerator is desired, this can be accomplished by tearing many slits in the accelerator.
8. The small, compact, and uniform size and weight of the accelerator was found to be quite a convenience and the average ash content, 0.00018 gram, of the accelerator was small enough to be disregarded for many commercial analyses but it could be quickly allowed for in results where the accuracy so required. M. W. G.

**Quantitative Separation of Iron from Gallium by Means of Alpha-Nitroso-Beta-Naphthol.** JACOB PAPISH AND L. E. HOAG. *J. Am. Chem. Soc.*, **50,** 2118–21 (Aug., 1928).—The method which is perhaps most commonly employed for separating gallium and iron takes advantage of the fact that when an alkali is added in excess trivalent iron precipitates while gallium, being amphoteric, goes into solution as the alkaline gallate. The method effectively separates iron from gallium, but does not effectively separate gallium from iron, due to the fact that the ferric hydroxide adsorbs appreciable quantities of it. Papish and Holt found that alpha-nitroso-beta-naphthol precipitates iron quantitatively from gallium salts. The authors have investigated the method and applied it to analytical work. They find that iron and gallium may be so completely separated by the method that spectroscopic tests show the iron to be free from gallium and the gallium to be free from iron. A. P. B.

**An Apparatus for Continuous Gas Analysis.** ERNEST C. WHITE. *J. Am. Chem. Soc.*, **50,** 2148–54 (Aug., 1928).—An apparatus is described for the continuous determination of moderate concentrations of a given constituent in a flowing gas mixture and for registering the concentration automatically by electrical means. The principle employed for this purpose is to scrub a definite proportion of the gas with a definite proportion of a suitable absorbent and to determine the titer of the resulting solution by measuring its electrical conductivity. The apparatus is fully described and a large detailed figure is given. Methods of calibration and application are discussed at length. A. P. B.

**The Atomic Weight of Cesium.** T. W. RICHARDS AND MARCEL FRANCON. *J. Am. Chem. Soc.*, **50,** 2162–6 (Aug., 1928).—The present value for the atomic weight, 132.81, is based primarily on the work of Richards and Archibald. In 1921 Aston found, by the mass spectrograph, that cesium appears to be a simple element with a mass number of 133.00 ± 0.2. There are very few cases of simple elements where such a discrepancy exists between the atomic weight and mass number, and it becomes

of great theoretical interest, from the standpoint of atomic structure and an understanding of the "packing effect" to check this weight. This was therefore undertaken by the authors. The work was completed before the death of the senior author, but written up afterwards. The elaborate technic used for such work is fully described and tables of data presented. The atomic weight is found, from the determined CsCl-Ag ratio, to be 132.809, confirming the present accepted value. A. P. B.

**A Simplified Method of Differential Potentiometric Titration.** NORRIS F. HALL, M. A. JENSEN, AND SVEN A. BAECKSTROM. *J. Am. Chem. Soc.*, **50,** 2217 (Aug., 1928).—The excellent differential method of MacInnes and Jones requires the use of a glass device of considerable complexity to temporarily withhold a small amount of solution from the titration while at the same time maintaining it in electrical contact. An extremely simple device is here described and illustrated, employing only a medicine dropper, which has given extremely satisfactory results in use. A. P. B.

**Diphenylcarbazide as a Test for Chromium.** NORMAN C. STOVER. *J. Am. Chem. Soc.*, **50,** 2363–6 (Sept., 1928).—A number of organic compounds have been proposed for detecting and estimating chromium when present as the chromate or dichromate. Of these diphenylcarbazide seems very promising. Accordingly the series of tests here described were carried out to compare it with the ether-dichromate-hydrogen peroxide test as usually applied. The authors describe the technic of the test and then present comparative figures. The ether-peroxide test will detect 1 part of chromium in 1,250,000; the diphenylcarbazide test using sulfuric acid, 1 part in 100,000,000 to 250,000,000, using acetic acid, 1 part in 71,000,000; using citric acid, 1 part in 12,500,000. It employs only one solution instead of two and dispenses with the use of ether, always a source of danger in the hands of beginning students. A. P. B.

**The Use of Picric Acid as an Artificial Standard in the Colorimetric Estimation of Silica.** E. J. KING AND C. C. LUCAS. *J. Am. Chem. Soc.*, **50,** 2395–7 (Sept., 1928).—The determination of the small amounts of silica usually present in natural waters is a slow and tedious process when the gravimetric method is employed. Dienert and Wandenbulcke have proposed a colorimetric method, based upon the production of a highly colored silico-molybdic acid. When dilute silica solutions are treated with an acid and ammonium molybdate, a color develops which exactly matches that of dilute picric acid solutions. Dienert and Wandenbulcke have proposed the use of an artificial standard containing 36.9 mg. of picric acid as corresponding to 50 mg. silica per liter. As a result of a series of colorimetric determinations of the silica content of marine waters on the west coast of Canada, in which unusually high values were obtained, the picric acid standards used were suspected of being at fault. Careful color comparisons with known silica solutions showed this to be the case. Tables of results obtained are given. It is shown that only 25.6 mg. of vacuum dried picric acid are required to exactly match the color of a solution containing 50 mg. silica per liter. A. P. B.

**A Modified Confirmatory Test for Aluminum.** E. H. PANGANIBAN AND F. A. SOLIVEN. *J. Am. Chem. Soc.*, **50,** 2428 (Sept., 1928).—Noyes' procedure for confirming the presence of aluminum by forming a bead of the blue cobalt aluminate is not satisfactory for class use by students, according to the authors. They would modify it by collecting the precipitate of aluminum and cobalt hydroxides on asbestos fibers instead of the filter paper. It is claimed that the precipitate thus collected requires no washing to remove sodium salts and that the ignition requires less time and gives a better bead. A. P. B.

**New Educational Motion Picture Film Depicting Hazards of Carbon Monoxide Ready for Distribution.** EDITOR. *Med. Progr.*, **44,** 217 (Sept., 1928).—The film, entitled "Carbon Monoxide: The Unseen Danger," prepared in coöperation with one of the large automobile manufacturing companies, shows vividly how this deadly gas may be encountered in workshop, garage, and home, points out ways of preventing accumulation of the gas, and visualizes methods of reviving victims of the gas.

Copies of this film may be obtained from the Pittsburgh Experiment Station, U. S. Bureau of Mines, Pittsburgh, Pa. No charge is made for the use of the film, but the exhibitor is requested to pay transportation charges. M. W. G.

## EDUCATIONAL MEASUREMENTS AND DATA

**Statistical Survey of Education.** FRANK M. PHILLIPS. *Bureau Educ. Bull.*, **12,** 1–13 (1928).—The statistics in the publication cover elementary schools, secondary schools, normals, colleges, and universities. Among the tables included are: "Per cent of total enrolments in schools under public control" for each ten-year period, beginning with 1890; school enrolments, expenditures, and per pupil costs, 1925–1926; gifts and bequests to education, 1918–1926; gifts and bequests to education, 1871–1926; distri-

bution of teachers for four ten-year and one six-year period; kindergarten, elementary, commercial, secondary, normal school, and college enrolments, 1890–1926; enrolment in certain types of schools, by states, 1925–1926. Four graphs present; percentage increase in enrolments, 1890–1926; junior high schools, 1910–1926; expenditures in public schools, 1916–1926; increase in average length of school life, 1800–1924. Data on college and high schools are given separate from totals in most tables and graphs.
B. C. H.

**Provisions for Individual Differences.** WALTER S. DIFFENBAUGH. *Bureau Educ. Bull.*, **11**, 34–6 (1928).—Survey reports upon public schools indicate that the percentage of non-promotions is too high. "Much remains to be done before all children may progress through school at the rate commensurate with their abilities and effort. In order better to provide for the individual child the survey contains the recommendation that children of like abilities be grouped together for the purpose of instruction and that the courses of study be adapted to the various ability groups." Ways of providing for individual differences are stated as: (1) grouping pupils and advancing the brighter children as rapidly as possible; (2) giving the brighter children more to do without advancing them rapidly from one grade to the other; and (3) adoption of an individual instruction plan. A brief summary of the survey of the Winnetka (Ill.) schools is given. This survey attempted "to evaluate an individual method of instruction."
B. C. H.

## KEEPING UP WITH CHEMISTRY

**The Use of Lead Tetra-Ethyl.** *Science*, **68**, 158 (Aug. 17, 1928).—Quotation from *The Times*, London, reporting the findings of a British committee of inquiry under Sir Frederick Willis. No legislative action against the use of lead tetra-ethyl is recommended as long as regulations are observed similar to those in force in the United States.
G. H. W.

**The Heat Treatment of Ferrous Metals.** C. M. WALTER. *Chem. & Ind.*, **47**, 791–7 (Aug. 3, 1928).—The author discusses the manner in which heat treatment affects the mechanical and physical properties of wrought iron, cast iron, and various kinds of steel. The influence of nickel, chromium, tungsten, molybdenum, vanadium, and cobalt, on the critical temperature ranges is noted. The article contains fifty micro-photographs: a short bibliography is included.
E. R. W.

**By-Products of Chemical Warfare.** AMOS A. FRIES. *Ind. Eng. Chem.*, **20**, 1079–84 (Oct., 1928).—See "Chemical Digest," THIS JOURNAL, **5**, 1505–9 (Nov., 1928).
M. W. G.

**Chemical Warfare against the Barnacle.** ANON. *Chem. Warfare*, **14**, 369–71 (July 15, 1928).—". . . there is scarcely a ship sailing the seas today whose speed is not reduced or whose fuel consumption is not increased due to the accumulation of barnacles on its bottom." It has been estimated that the loss due to increased fuel consumption amounts to about $75,000,000 a year. Various attempts to prepare surfaces to which the barnacle could not attach itself have ended in failure. "It has been found, however, that barnacles are repelled by certain toxic chemicals, and the incorporation of these chemicals in ship bottom paint gives some promise of providing a solution of this problem." A number of such paints have been prepared by the Chemical Warfare Service and are now being tried by the Navy Department. The tests so far have given excellent results.
E. R. W.

**White Pine Blister Rust in Michigan.** D. J. STOUFFER. *Mich. Educ. J.*, **6**, 60 (Sept., 1928).—Currant and gooseberry bushes are the alternate hosts for the white pine blister rust. A school campaign against this destructive disease has been planned to start about the middle of September.
E. R. W.

**Reclaiming Used Cylinder Oil.** EDITOR. *Silicate P's & Q's*, **8**, No. 9 (Sept., 1928).—There are two steps essential in restoring its lubricating value to oil: (1) ridding it of solid particles so all may be clear and thin; (2) removing the light ingredients of the oil that its original viscosity may be renewed. The General Electric Company has coöperated with the Hilliard Corporation and they now have an apparatus which reclaims the oil almost automatically. The contaminated oil flows into the apparatus, is shaken with the proper quantity of silicate, and is floated on water from which the sludge is cautiously removed. "The refined oil then flows as a thin film over metal surfaces electrically heated so that the light oil is driven off and the lubricant is delivered by the machine in condition to put back into automobile." The cost is "substantially less than the price of new oil and the refined oil is said to actually be the better lubricant." Photographs and a diagram are included in the paper.
B. C. H.

**Balloons—Balloons.** L. C. PORTER AND A. C. RAY. *Gen. Elec. Rev.*, **31**, 264

(May, 1928).—The demand for a soft, decorative light, rich in color, has resulted in the use of ordinary ten-inch rubber balloons into which have been inserted electric light bulbs. Such a scheme was used for lighting the spacious grounds of the Broadmoor Hotel at Colorado Springs. Rubber imitations of rabbits, donkeys, frogs, etc., may be substituted for spherical balloons.

Suggestions for color combinations and methods for setting up and operating such a lighting system are given.

The installation can be quickly made. E. L. M.

**Electricity and Compressed Gases.** EDITORIAL. *Gen. Elec. Rev.*, **31,** 341 (July, 1928).—The use of "compressed gases" as an industrial utility is rapidly increasing. It may soon be classed with the three recognized industrial utilities: power, light, and heat. The expansion of chemical industries and the increasing knowledge of the utility of these gases in manufacturing operations account for the rapid rise in the use of compressed gases in industry. Some industrial applications mentioned are: gas cutting instead of machine cutting, nickel plating, lead burning, welding, brazing, and annealing (preliminary treatment with atmosphere of hydrogen or hydrogen-nitrogen improves the quality of the processed product).

For the production of these gases electrical energy serves best so that the two are intimately connected. E. L. M.

**Combustion Symposium.** *Ind. Eng. Chem.*, **20,** 988–1044 (Oct., 1928).—Papers presented before the joint symposium of the Divisions of Gas and Fuel Chemistry and Petroleum Chemistry at the 76th Meeting of the A. C. S., Swampscott, Mass., Sept. 10–14, 1928. M. W. G.

**The Second International Nitrogen Conference.** F. E. BEAR. *Ind. Eng. Chem.*, **20,** 1112–6 (Oct., 1928).—The first international nitrogen conference, held at Biarritz, France, in 1926, having proved worthwhile, a second conference was called for 1928. This second conference, sponsored by the nitrogen syndicates of France, Italy, Norway, England, and Germany was held on board the S.S. *Lutzow* sailing from Venice and cruising the Adriatic Sea from April 30th to May 8th. Altogether fifteen countries were represented, including the United States and Canada. About one hundred and fifty people were in attendance.

The titles listed below of the papers discussed in this report indicate the various matters relating to the production and utilization of nitrogen fertilizers considered by the delegates. "Nitrogen Economics," Julius Bueb; "Problems Involved in Increased Production and Consumption of Nitrogen Fertilizers," F. C. Speyer; "Agricultural Education," Sir Frederick Keeble; "Economic Principles of Fertilizer Use," Herman Warmbold; "Crop Intensification in Relation to Plant Breeding," Erwin Baur; "Chemistry of Intensively Treated Grassland," H. J. Page; "Comparison of Ammoniacal and Nitrate Nitrogen as Fertilizers," A. Demolon; "Irrigation and Liming in Relation to Use of Nitrogen Fertilizers," J. Galland; "Fertilizer Problems of India," T. H. J. Carroll; "Concentrated Nitric Acid by Ammonia Oxidation under Pressure," G. Fauser. M. W. G.

**Synthetic Ammonia.** P. FIRMIN. *Industrie chimique*, **15,** 297–302 (1928); cf. *C. A.* **22,** 1017 (March 20, 1928); 3492 (Sept. 20, 1928).—A review comparing the different processes in use. M. W. G.

**Explosives and Their Properties.** I. GRAGEROFF. *Mining J.* (U. S.) **11,** 13–4 (1928); *C. A.*, **22,** 3531 (Sept. 20, 1928).—A discussion of the many known properties which enter into complete utilization of the potential power of explosives. M. W. G.

**Lead and Articles Manufactured from It.** BRENTHEL. *Chem.-Ztg.*, **52,** 169–70, 190–2, 250–2 (1928); *C. A.*, **22,** 3379 (Sept. 20, 1928).—A lecture outlining the metallurgy, properties, and uses of Pb and its alloys. Lead sheet, pipe, valves, pumps, cable covering, and apparatus for use in the chemical industry are given special consideration. M. W. G.

**Beryllium: A Survey.** A. C. VIVIAN. *Mining Mag.*, **38,** 220–2 (1928). M. W. G.

**The Science of Colloids and Its Applications.** HENRI BRAIDY. *Industrie chimique*, **15,** 294–6 (1928); *C. A.*, **22,** 3330 (Sept. 20, 1928).—The first article of a review on colloids. This article deals with the meaning of the word colloid and also with the structure of colloids. M. W. G.

**Applications of Glass to the Chemical and Allied Industries.** A. E. MARSHALL. *Chem. & Ind.*, **47,** 243T–7T (Aug. 24, 1928).—The manufacture of glass is one of the oldest of the arts, dating from some time "prior to 3000 B.C." The earliest glasses were often translucent or even opaque, although transparent glass has been known for 4000 years. Transparency is the most important property of glass, being responsible

for the use of over 95% of the glass manufactured. Attempts have been made to manufacture a tougher and less fragile glass so that it might be used as a structural material. Although modern building methods have largely done away with the need for glass as a building material, Pyrex, which is an improved glass as regards ruggedness and heat resistance, is finding new and varied uses in the construction of laboratory and plant equipment. Pyrex has the lowest coefficient of linear expansion of any of the materials commonly used in such construction. E. R. W.

**Mongolian Distillation Apparatus.** E. HUBER. *Chem. App.*, **15,** 145–7 (1928); *C. A.*, **22,** 3323 (Sept. 20, 1928).—Historical. M. W. G.

**Count Rumford—Scientist and Philanthropist.** LYMAN C. NEWELL. *Science*, **68,** 67–73 (July 27, 1928).—An account of the extent, variety, and originality of Rumford's work as a scientist and a philanthropist. In concluding, the author states: "One marvels that so much of his work was practical and useful, though planned by a scientific investigator and pursued in most cases solely to discover facts. One wonders, also, how he found time and strength to perform and record such a vast number of experiments. In this address much of his work has been left untouched, but enough has been considered to demonstrate that Count Rumford was a wonderful man and undeniably deserves the high place given him among the world's most famous scientists and philanthropists."

Note: The September, 1928, issue of THIS JOURNAL contains a portrait of Count Rumford as a frontispiece, an editorial regarding him, and a picture of Count Rumford's birthplace, page 1178. M. W. G.

**Ellwood Hendrick.** CHAS. F. ROTH. *Ind. Eng. Chem.*, **20,** 978–9 (Sept., 1928).—An intimate account, with portrait, of Ellwood Hendrick who has "become the poet of chemistry and the prosaist of science," at present curator of the Chandler Museum of Columbia University, and director and member of the executive committee of The Research Corporation. M. W. G.

**Edward Granville Nellis. An Appreciation.** M. C. WHITAKER. *Ind. Eng. Chem.*, **20,** 984 (Sept., 1928). M. W. G.

**Jean-Baptiste Dumas.** C. MATIGNON. *Rev. Sci.*, **65,** 417–24 (1926); *C. A.*, **22,** 3072 (Sept. 10, 1928).—An address, with portrait, reviewing Dumas' career. M. W. G.

**Alessandro Volta and His Times.** GIOVANNI CAU. *Rev. Sci.*, **65,** 481–7 (1927); *C. A.*, **22,** 3072 (Sept. 10, 1928).—Biographical, with portrait. M. W. G.

**In Memory of H. A. Lorentz.** VITO VOLTERRA. *Nuovo cimento* (N. S.), **5,** 41–3 (1928); *C. A.*, **22,** 3072 (Sept. 10, 1928).—Obituary with portrait. M. W. G.

**Antoine Baumé (1728–1804.)** ANON. *Chemist and Druggist*, **108,** 198 (1928); *C. A.*, **22,** 2690 (Aug. 10, 1928).—Biography and portrait of B., commemorating the bicentenary of his birth. M. W. G.

**Sir James Dewar (1842–1923).** H. E. ARMSTRONG. *J. Chem. Soc.*, **1928,** 1061–6; *C. A.*, **22,** 2690 (Aug. 10, 1928).—An obituary. M. W. G.

**Ernst Beckmann (1853–1923).** G. LOCKEMANN. *Ber.*, **61A,** 87–130 (1928); *C. A.*, **22,** 3323 (Sept. 20, 1928).—Biography with portrait and bibliography. M. W. G.

**Ignác Moscicki, President of the Polish Republic, as Technologist.** JAROSLAV MILBAUER. *Chem. obzor.*, **3,** 1–3 (1928); *C. A.*, **22,** 3323 (Sept. 20, 1928).—A biography with portrait, and a short description of his work. M. W. G.

**Roger Bacon's Gunpowder and His Secret Wisdom.** TENNEY L. DAVIS. *Ind. Eng. Chem.*, **20,** 772–4 (July, 1928).—Roger Bacon's description of the preparation of the "Philosopher's Egg" (by which name he means black powder), with numerous comments by the author, is presented. A discussion of the three contraries—knowledge, will, and power—concludes the article. M. W. G.

## THE PHILOSOPHY OF SCIENCE

**Available Energy.** R. A. MILLIKAN. *Ind. Eng. Chem.*, **20,** 1117–21 (Oct., 1928); *Science*, **68,** 279–84 (Sept. 28, 1928).—Messel Medal address. See "Chemical Digest," THIS JOURNAL, **5,** 1501–5 (Nov., 1928). M. W. G.

**Craftsmanship and Science.** SIR WILLIAM BRAGG. *Science*, **68,** 213 (Sept. 7, 1928).—Presidential address before British Assoc. for Adv. Science. See "Chemical Digest," THIS JOURNAL, **5,** 1509–14 (Nov., 1928). G. W. H.

## THE METHODS AND PHILOSOPHY OF EDUCATION

**Supervision of Instruction in Higher Education.** W. F. SANDERS. *Sch. & Soc.*, **28,** 163–6 (Aug. 11, 1928).—Maintaining that instruction in higher education is ineffective, the author quotes Klapper's four causes of ineffective teaching and also gives results of a questionnaire sent to 267 institutions.

Too constant use of the lecture method, failure to apply teaching to everyday life and a lack of knowledge of teaching technic seem in large measure to be responsible for ineffective teaching. All these could be improved if there were more supervision of college teaching. The most satisfactory method would seem to be a dean of instruction who would devote all his time to improving the quality of college teaching.
K. S. H.

**Foundations, Universities, and Research.** HAROLD J. LASKI. *Harper's*, **157,** 295 (Aug., 1928).—No university is complete today without its research institute. These institutes report to the universities; the universities to directors of foundations; the directors to trustees; the trustees seek reports from outsiders on these reports. Trustees expect presidents to pick professors likely to attract endowments from foundations; professors search for healthy young graduates who can provide the basis for ultimate generalizations. There are endless committees to coördinate or correlate or integrate. There are interim, special, confidential, and final reports. There are surveys for the dissection of every problem with experimental, statistical, and analytical centers.

The author doubts whether the results to be achieved are likely to be proportionate to the labor involved; whether the effect upon the universities is likely in the long run to be healthy; and whether the result of the policy will not give to the foundations a dominating control over university life which they quite emphatically ought not to have. Reasons for these doubts are stated.
J. W. H.

## THE TEACHING PROFESSION

**Things I Have Learned during Ten Years of Teaching.** BERNICE B. HURLBURT. *School*, **39,** 1014 (August, 1928).—A teacher should take a mental inventory much as a business man takes a stock inventory. Miss Hurlburt sets a pattern. Among the knowledge increments which have been hers during the period are: "(1) advisability of minding my own business, (2) the beauty of the square deal—this involves an attempt to judge by motives rather than actions, (3) that the first and last word in child discipline is self discipline, (4) I believe in the economy of words, (5) I have a small motto—something new every day, but neither shun nor pay unseemly court to the 'latest.' "
B. C. H.

**Permanent Membership in the Teaching Profession.** C. F. ARROWOOD. *Sch. & Soc.*, **28,** 177–9 (Aug. 11, 1928).—The writer discusses the reasons for short tenure in teaching positions and suggests centralized administration as a means of checking this difficulty.
K. S. H.

**Rating the Teaching Effectiveness of College Instructors.** H. R. DOUGLASS. *Sch. & Soc.*, **28,** 192–7 (Aug. 18, 1928).—Since few students possess superior ability the problem of effective teaching is more or less vital.

Of late, American universities have assumed the German attitude that research is of much greater importance than good teaching. In many institutions men frequently pride themselves on poor teaching but take great credit for being good research workers. This situation is decidedly wrong and considerable stress should be put upon effective teaching.

In connection with the question as to how good teaching is to be measured, several possibilities are discussed at length. The author concludes with, "Efforts should be expended to improve the technic and spirit of instruction in university classes."
K. S. H.

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**Mercury Arc Best for Damaging Paints.** If you have any paints that you want to destroy by the action of light, the mercury vapor arc is best for the purpose. So, in effect, members of the Paint and Varnish Division were told at the recent meeting of the American Chemical Society at Swampscott by F. C. Schmutz and D. L. Gamble.

The speakers were referring to the use of light in testing weathering of painted surfaces. Since it takes too long to find out the effect of years of weathering on paints by actually exposing them to the elements, the testing laboratories have developed methods of getting an accelerated weathering by artificial means. Other light sources that were tried were natural sunlight, and the carbon arc, with special carbons. In order to get effects similar to sunlight it was found best to enclose the mercury arc in special glass filters to cut out the very short ultra-violet rays.—*Science Service*

# Local Activities and Opportunities

Through these columns, the JOURNAL desires to render a two-fold service.

1. **Local Activities.** Keeping its readers in touch with the varied interests of institutions, A. C. S. sections, teachers' asssociations, and other organizations throughout the country. Items of general interest would include: (1) notices of local scholarships or fellowships; (2) notices of any special gifts to chemical organizations or departments—as fellowships, endowments, laboratory gifts, library gifts, etc.; (3) accounts of meetings, social functions, exhibitions, chemical entertainments, etc., which might be suggestive to other organizations (where original or unusual features are included it is desirable that they be described in some detail); (4) news notes concerning persons of sufficient prominence in their respective fields to make their movements of general interest; (5) promotions within, or changes of, personnel of a department; (6) announcements of new or unusual courses in chemical education or special fields of chemistry; (7) notes on new chemistry buildings or laboratories, stressing the unique features.

2. **Opportunities.** Providing an exchange column for positions. That is: (1) any teacher, who is a subscriber to the JOURNAL, desiring to change his position, may advertise once a year without charge (correspondence will be handled through the editorial office, if desired); (2) any notices of vacancies, in which chemistry teachers and chemists will be interested, will also be published.

The responsibility of reporting items for this section rests entirely with the local institutions and organizations. It would be desirable to have some person connected with each organization and institution appointed to report regularly.

Suitable material sent to the editorial office before the 20th of each month will be published in the following month's JOURNAL. The Editorial Staff must necessarily reserve the right to abridge or totally reject any items submitted. If the above suggestions are followed however the necessity for such action will be largely obviated.

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**The University of Kansas.** Dr. Robert Taft of the department of chemistry of the University of Kansas has been promoted to the rank of associate professor.

Extension courses in chemistry for graduates and undergraduates are being given in Kansas City by the chemistry department of the University of Kansas. Last year Professor Robert Taft gave a course in "General Physical Chemistry." Professor R. Q. Brewster is giving a 3-hr. course this semester on "A Critical Review of the Paraffin Series of Carbon Compounds."

On October 5th Dr. H. P. Cady, of the University of Kansas Chemistry Department, gave an address at the annual meeting of the Northeast Minnesota Teachers' Association in Duluth, Minnesota, on the "Conquest of Helium."

**University of Florida.** Dr. T. R. Leigh, Dean of the College of Pharmacy and Head of the Department of Chemistry, and Dr. B. V. Christensen attended the Portland meeting of the American Pharmaceutical Association in August. Dr. Leigh is chairman of the chemistry section of the teachers' conference, and Dr. Christensen read two papers. The Florida college was one of three to receive a portion of the research grant of the American Public Health Association.

Prof. A. P. Black was dean of men during the summer session. He attended the Swampscott Meeting of the A. C. S. in September.

Dr. W. H. Beisler spent the summer in special research work.

Dr. F. H. Heath was a member of the summer school faculty, and in addition continued special research on the platinum metals.

Dr. V. T. Jackson spent the summer touring Europe and making an inspection of the chemical laboratories of foreign institutions. He touched particularly England, Scotland, Germany, Belgium, France, Italy, and Switzerland.

Prof. R. C. Goodwin received the Ph.D. degree from Harvard University in June.

**University of Oregon.** Dr. Leo Friedman has been added to the teaching staff. He comes with high recommendations from the graduate school at the University of Wisconsin. He replaces Mr. H. G. Tanner who is remaining at Stanford for a second year of graduate work with Dr. McBain.

**New England Association of Chemistry Teachers.** The 112th meeting of the New England Association of Chemistry Teachers was held at Northampton, Mass., on Saturday, October 20, 1928. Three industrial trips were enjoyed in the morning; one through the plant of the Corticelli Silk Company, another through the plant of the Prophylactic Brush Company, and a third through the plant of the McCallum Silk Company.

The business meeting was called to order at 2.00 P.M. in Stoddard Hall by the President, Professor Joseph S. Chamberlain of M. A. C. Reports were given by Robert W. Cobb of Springfield, Mass., for the New Apparatus Committee and Elbert Weaver of Hartford, Conn., for the Industrial Trip Committee. Prof. G. Albert Hill of Wesleyan, Chairman of the Western Division, introduced Prof. Joseph S. Chamberlain who gave an interesting talk on "Teaching and Research."

**Mellon Institute Radio Talks, 1928–1929.** The following series of fifteen discourses on "Science for the Home Manager," by research specialists of Mellon Institute will be broadcast from the University of Pittsburgh Studio of Westinghouse Station KDKA during the university year 1928–1929. The talks, which are to be given on Tuesday afternoons at 1.45 o'clock, will be intended especially for home managers and students of home economics. The speakers will accord particular attention to recent advances in scientific knowledge that are of practical value in home-making and housekeeping.

1. November 13: "Sanitation in the Home," by Dr. C. D. Beal.
2. November 20: "Soap, the Agent of Cleanliness," by Dr. R. B. Trusler.
3. November 27: "Extermination of Pests," by Dr. O. F. Hedenburg.
4. December 4: "Selection of Sleeping Equipment," by Dr. H. M. Johnson.
5. December 11: "Care of the Bedroom," by Dr. T. H. Swan.
6. December 18: "Foods That Are Most Healthful," by Mr. E. R. Harding.
7. January 8: "Place of Milk in the Diet," by Mr. R. R. Irvin.
8. January 15: "Selection and Care of Kitchen Equipment," by Dr. E. W. Schwartze.
9. January 22: "Plants for the Home," by Dr. O. E. Jennings.
10. January 29: "Heating of the Home," by Mr. R. H. Heilman.
11. February 5: "Healthful Ventilation," by Mr. R. H. Heilman.
12. February 12: "Fire Risks and Prevention," by Mr. H. S. Coleman.
13. February 19: "Carpets and Draperies," by Mr. L. E. Jackson.
14. February 26: "When Painting Is Needed," by Mr. H. K. Salzberg.
15. March 5: "Residential Roofings," by Mr. Henri Marc.

**University of Nevada.** Professor William M. Hoskins is on leave of absence from his duties at the University of Nevada this year. He is spending the year as visiting professor at the University of California, where he is engaged in research in physiological chemistry. Professor Hoskins' place is being filled by Dr. R. D. Cool, who received his doctorate in June, 1928, at the University of Virginia, where he was du Pont Fellow during 1927–28. Mr. Francis Horton, Jr., A.B., University of Redlands, 1928, has come to us as Fellow in Chemistry.

The Chemistry Club, composed of students and faculty in the department, has been especially fortunate this year in having so far three outside papers, as follows:

On September 20th, Mr. Marc Le Duc, of the Great Western Electric Chemical Company, Pittsburgh, California, spoke on "Industrial Processes in the Manufacture of Caustic Soda and of Liquid Ammonia."

On September 27th, Mr. Henry A. Doerner, Associate Chemist of the United States Bureau of Mines, Rare and Precious Metals Experiment Station, presented a paper entitled "The Metallurgy

of Carnotite." Mr. Doerner was with the Bureau of Mines in Denver a number of years ago and, while there, actively engaged in the technical supervision which the Bureau exercised over the operations of the National Radium Institute.

A paper on "Ephedrine" was read, October 4th, by Mr. M. R. Miller of the Nevada Agricultural Experiment Station. Special emphasis was laid on the possible occurrence of ephedrine in plants native to Nevada.

**Ohio State University.** Dean William McPherson has resigned the chairmanship of the chemistry department of the Ohio State University, in order that he may devote practically all his time to the upbuilding of the graduate work of the university. He will however retain his chair of organic chemistry. He will be succeeded as chairman of the department by Dr. Wm. Lloyd Evans. In accepting Dr. McPherson's resignation the board of trustees passed the following resolution: "That the board of trustees expresses to Professor William McPherson its deep appreciation of the high quality of the service he has rendered as chairman of the department of chemistry through the years beginning in 1894. The board realizes that the very extensive and intensive growth of the department in the number and the quality of its courses and in the interest of the students, and the very high rank which the department has attained, are primarily due to the constructive policies pursued by Professor McPherson and to his rare ability to do a very large volume of work and a rare grade of teaching himself and at the same time to make skilful selection of the department staff and to inspire the members with his own enthusiasm. For his outstanding accomplishments in this great field of science the university will forever hold Professor McPherson in the highest esteem."

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**Noted British Scientist Measures Speed of Lightning.** The speed of a lightning flash has been measured for the first time in history. It takes about one-seven-thousandth of a second for it to complete itself. No part of it lasts more than approximately one-thirty-five-hundredth of a second.

The old dispute, as to whether lightning strikes downward from the clouds or jumps upward from the ground, has also been settled. It does both. It starts from the cloud and the ground at nearly the same instant, and approximately one-seven-thousandth of a second later the two ends unite in mid-air.

These facts, representing the first actual measurements of the speed of lightning, were determined by Prof. C. V. Boys, noted British physicist, who spent the summer at the private laboratory of Alfred L. Loomis, Tuxedo Park, N. Y. Prof. Boys obtained his measurements with a special camera which he has patiently carried about the world for 26 years, attempting hundreds of photographs in vain, until a New York stroke of lightning proved to be his real stroke of good luck.

The camera has two lenses instead of the usual single lens. They are mounted on a disk and whirled rapidly while the camera is pointed at a cloud which promises good lightning flashes. When the flash comes, the camera is closed and the plate developed.

Since two moving lenses have been used, a double picture is obtained, each image slightly displaced in a direction opposite to the other. By appropriate optical measurements and geometrical calculations of this displacement the direction and rate of travel of the flash can be determined. Its duration can be learned from the width of the streaks on the plate, blurred by the motion of the lenses.

A detailed report of Prof. Boys' lightning measurement and a description of the methods employed are published in a recent issue of the British scientific periodical, *Nature.—Science Service*

# Recent Books

**The Story of Chemistry.** FLOYD L. DARROW. Bobbs-Merrill Company, New York, 1927. viii + 528 pp. 22 figures. 16 × 24 cm. $4.00.

This volume is an attempt to sketch the historic background of the science of chemistry from the time of the alchemists to the present day. Just enough of the underlying facts and principles of chemical science has been included. The emphasis is upon research and recent developments. It is written for non-technical consumption and does not claim to be an encyclopedia of chemical information; many phases of chemical industry have been purposely omitted. The first chapter, entitled The Alchemist, is followed by one on After the Alchemist, then Atoms, Electrons, and Protons. Other chapters follow on Power, Gases, Agriculture, Disease, Rubber, Metals, Synthetics. The book is written with the American reader in mind and closes with chapters on American Progress in Chemistry and Research: The Key to Future Progress.

The first chapters of the book are a very successful attempt to reveal the development of chemistry as a *science*. The story of the alchemists and the manner in which modern chemistry is indebted to them for the urge to investigate is delightfully told. Toward the close of the volume the author lapses somewhat from his purpose to avoid the encyclopedic, but gives a sane account of important phases of chemical discovery, and refrains from terming them miracles and wonders.

Recent years have seen much written on what chemistry does, but not enough on what chemistry is. There is real need for books which will set forth the method of chemistry rather than a cataloging of fantastic facts and a lauding of the spectacular. In this volume the author has taken a substantial first step, but only a first step in this direction. The task of selecting the significant and discarding the less important is always difficult. One wishes the author had omitted even more.

The teacher of general chemistry will wish to refer students to the section dealing with chemistry's historical background; it is superior to that in the textbooks. As a story for the layman it is delightfully told, without the use of formulas and technical terms, and without the feeling that the language has been stepped down to his level. It is a pleasure to find new material and new anecdotes to replace the traditional episodes and the hackneyed style of the familiar chemistry-in-daily-life type of book.

WM. H. ADOLPH
UNIVERSITY OF NEBRASKA

**Recent Advances in Chemistry in Relation to Medical Practice.** W. MCKIM MARRIOTT, B.S., M.D., Dean and Professor of Pediatrics, Washington University School of Medicine, Physician-in-Chief, St. Louis Children's Hospital. The C. V. Mosby Co., St. Louis, 1928. 141 pp. 12 figures. 15 × 23 cm. $2.50.

The six lectures which comprise the subject matter of this book are from the Series of 1927 Lectures of the San Diego Academy of Medicine. The lectures are entitled: "Fundamental Chemical Considerations;" "Acidosis and Alkalosis;" "The Chemistry of the Blood;" "Foods and Metabolism" (two lectures); "The Endocrines." The author states in the preface: "It is the purpose of these lectures to summarize present knowledge concerning certain important phases of chemistry and to point out, in so far as possible, the clinical applications of chemical

principles. The lectures do not deal solely with a consideration of those phases of chemistry which are of immediate clinical application. Fundamental chemical conceptions are discussed at length, for it is only with a full understanding of the nature of chemical processes that intelligent applications may be made. Throughout the lectures general principles rather than details are discussed, for a knowledge of details may readily be acquired, once one's interest in the subject has been fully aroused."

Most chemists who have had neither physiological chemistry nor pharmacology should find this book well worthwhile. It is written clearly, logically, briefly, and interestingly. One might question whether the title of the book is a fortunate one. It would seem that "Recent Applications of Chemistry in Relation to Medical Practice" would be a title more in keeping with the spirit of the book than the title "Recent Advances—." Organic chemists, at least, are inclined to believe that some of the "Recent Advances" are due to them, yet almost no mention is made of their work. In this sense, therefore, the title is misleading. It is of interest to note that an unusual typographical error occurs on the title page which immediately precedes Lecture I; there the title of the book is boldly listed as "Recent Advantages in Chemistry in Relation to Medical Practice."

The "sins" of the book appear to be more largely those of omission than of commission. The former may be justified, certainly, when it is realized that six lectures only were included. One feature of the book at least will undoubtedly offend many of the chemical readers; namely, the use of hydrochloric acid (p. 20) to illustrate the mass law. Also, it would seem that some better explanation of the fact that $H^+$ and $Cl^+$ ions, but not $Na^+$ or $K^+$ ions, permeate the red blood cells could be found than the equation (p. 40): $NaCl + H_2CO_3 \rightleftharpoons HCl + NaHCO_3$.

All chemists should know more than a smattering of such topics as acidosis, alkalosis, ketosis, pH, vitamins (spelled in the text as vitamines), "calories" in relation to diet, food fads, diets in relation to various states of health and ill health, hormones, and similar topics. Dr. Marriott's book may well be recommended for such a purpose.

CHARLES D. HURD
NORTHWESTERN UNIVERSITY

**Organic Chemistry. A Brief Introductory Course.** JAMES BRYANT CONANT, Harvard University. The Macmillan Co., New York, 1928. ix + 291 pp. 14 × 21.5 cm. $2.60.

This book is one of a few recent texts in organic chemistry in which "the author has unhesitatingly departed from the traditional arrangement of the subject matter whenever such departure seemed to promise a more interesting grouping of topics or an easier road to a mastery of the principles of the science. The usual introductory chapter dealing with the purification of compounds, methods of analysis, and the calculation of formulas has been omitted."

"The author's experience in presenting organic chemistry to a variety of classes has led him to believe that the alcohols have certain advantages over hydrocarbons as a point of departure." We read further: "The value of the paraffin hydrocarbons to the systematist has, in the author's opinion, led to an overemphasis of their pedagogic importance."

In the foreword, organic chemistry is defined as the chemistry of the compounds of carbon and attention is called to the variety of its applications. The chapters, in the order of their presentation, are entitled: alcohols; ethers, alkyl halides, esters; petroleum; unsaturated hydrocarbons, rubber; organic acids; esters, fats, oils, and soaps; derivatives of ammonia—amides, amines, urea; aldehydes and ketones; synthesis of organic compounds; polyhalogen compounds,

methods of determining the structure of complicated organic substances; dibasic acids and hydroxy acids; stereoisomerism; carbohydrates, malonic ester, and acetoacetic ester; hydrocarbons from coal tar; aryl halides and phenols; aromatic nitro compounds and amines; aminophenols and polyhydroxy compounds; diazonium salts and azo dyes; aromatic acids; aliphatic compounds with aryl groups; natural and synthetic dyes and drugs; proteins.

Having abandoned the hydrocarbons as a point of departure and the usual systematic order of presentation the author seems impelled by a purely utilitarian motive. In the chapter on petroleum we read:

"The alcohols and alkyl halides are often spoken of as derivatives of the paraffin hydrocarbons. A *derivative* is a substance which *might* be prepared from the hydrocarbon by the replacement of a hydrogen atom by a group or an atom. This is a purely formal relationship which is useful in classification. It does not state that the derivatives of the hydrocarbon are prepared in this way. Indeed we shall see that they almost never are!"

Consistent with this point of view the process of substitution is not discussed in that part of the text dealing with aliphatic compounds. The specific terms chlorination, bromination, or halogenation are always used. Saturated hydrocarbons are first defined in the introductory paragraph of the chapter on unsaturated hydrocarbons. The original significance of the term paraffin is not disclosed.

The several series of organic compounds are so closely inter-related that it will always be difficult to find an order of presentation which does not either anticipate a knowledge of compounds not yet discussed or delay certain topics so that the discussion becomes disconnected. The new order of presentation does not seem to have improved the situation in this particular. For example, having discussed the alcohols in Chapter I the author finds it necessary to return to the subject on four separate occasions to complete the discussion. Alcohols, carboxylic acids, and aldehydes are taken up in the order given. The alkyl halides receive separate treatment from the inorganic esters because of their distinctive characteristic of forming Grignard reagents. The discussion of ethers, preceding these two topics, anticipates both.

No two authors would select quite the same material for so brief a text. In the present case the usual chapter on the synthesis of the homologs of benzene has been omitted and the material included in the discussion of aryl halides and aromatic ketones. The chapter on heterocyclic compounds is also omitted although furan, pyrrole, pyridine, and indole are treated briefly in the chapter on natural and synthetic dyes and drugs. Quinoline and isoquinoline are not mentioned and the classification of alkaloids is not given. In view of these facts the reviewer was surprised to find more than eight pages devoted to malonic ester and acetoacetic ester. While the example of tautomeric equilibrium afforded by acetoacetic ester is almost classical it is also true that the material in this chapter is very complex. Beginning students will always confuse complexity with importance and will spend hours committing to memory the stepwise reactions of the malonic ester syntheses but at the same time will neglect the simpler and more fundamental reactions.

The questions and problems at the end of the chapters are well designed for purposes of instruction, but the beginning student will no doubt be puzzled when he encounters the mixed type of amine for the first time in the questions at the end of the chapter on ammonia derivatives.

The book is to be commended for its brevity. Too many of our textbooks in organic chemistry tend to become compendiums. The material is well selected and the discussions are clear and forceful. The industrial applications of

organic chemistry have been brought up to date and form a distinctive feature of the text. Much tabulated material has been used to advantage, the drawings are well executed, the printing and binding well done, and the typographical errors few.

The reviewer differs fundamentally from the author as to what constitutes the aim of an elementary course in organic chemistry. Such a course should afford the student an opportunity to do two things: *first*, to learn the chemical characteristics of the typical functional groups, and *second* to acquire at least a reading knowledge of structural organic chemistry, including the inter-relation of the several typical series of compounds. The present text does the first of these in a splendid fashion. As to the second, while the subjects of isomerism, homology, and proof of constitution are adequately treated, there is little hope that the student will gain a proper perspective of systematic organic chemistry—the hydrocarbons and their derivatives.

Science has been defined as classified or systematized knowledge. Organic chemistry is one of our most perfect examples. The reviewer believes the elementary student is entitled to a systematic presentation of the subject. After carefully reading the book, he is still of the opinion that a more logical and, perhaps, an equally interesting approach to organic chemistry may be had through methane and its derivatives.

CECIL E. BOARD
OHIO STATE UNIVERSITY

**High-School Chemistry.** GEORGE HOWARD BRUCE, Horace Mann School for Boys, Teachers' College, Columbia University. World Book Co., New York, 1928. x + 550 pp. 147 illustrations. 12.5 × 18.5 cm. $1.68.

With a background of several years' experience in teaching, and after the use of this book in mimeographed form for three years in his own classroom, the author has embodied in this text the material, methods, and order of presentation which he believes best suited for use in the secondary school. The preface enumerates some of the noteworthy points: *viz.*, "short paragraphs, listing of physical and chemical properties in tabular form; the printing of equations, definitions, terms, and emphasized words in bold-face type; the list of topics in column form at the beginning of each chapter; and full questions and problem lists at the ends of chapters."

The language of this text is readily understandable by the ordinary student. Definitions are generally clear. The use of so much bold-face type, as indicated above, often gives the page a "spotty" appearance.

Chemical equations are used from the very first, each formula in the early pages being accompanied by the name of the substance it represents. Later in the book some of the more complicated equations, such as that for the reaction between copper and sulfuric acid or nitric acid in the preparation of sulfur dioxide and nitric oxide, respectively, might well be made more understandable by showing the intermediate equations.

The text is strongly committed to the electron theory, beginning with Chapter V, atoms and molecules, and the theory is brought in again and often in connection with such matters as: valence, equations, oxidation and reduction. The atomic numbers of the elements are given in a table on page 88 in a manner not readily understood until the accompanying text is read, and again on page 348. The chart for the periodic table, however, does not give the atomic numbers.

The electromotive series is considered important enough to be given twice, once on page 220 and again on page 351, with an excellent summary of the important ideas associated with the series. This series might, in the reviewer's judgment, be given much earlier, perhaps in connection with the chapter on hydrogen, as a simple explanation of the reasons

why certain metals cannot be, and other metals are not, used in the preparation of hydrogen by their reaction with an acid.

One is pleased to note that in the solution of stoichiometric problems the old style of proportion, $A:B::C:D$, has been abandoned in favor of the fractional form now used by all the best teachers of mathematics.

The book contains some items, such as the Law of Raoult, the Law of Henry, and the generalization of Dulong and Petit, which are frequently omitted from elementary chemistries. On the other hand, some items might well have been omitted, such as the moribund LeBlanc process which is now only of historical interest in this country.

There will be differences of opinion as to the order of chapters but the reviewer would prefer to have the three chapters on organic chemistry, now at the end of the book, follow the chapter on the compounds of carbon, and the chapter on halogens follow the one on chlorine and hydrochloric acid.

It is of course impracticable to attempt to list all the recent developments and applications of chemistry in an elementary text but one regrets the omission of: atomic hydrogen flames; hydrogenation of soft coal; Duco finishes; bakelite; ore flotation; adequate treatment of explosives, war gases, and the use of nitrites in dye manufacture; and other similar material. Energy is not treated with the fullness it deserves. Revision will probably care for these omissions.

In the treatment of the metals the author has shown a good sense of proportion by giving to such elements as barium, strontium, cadmium, cobalt, nickel, and manganese but a small amount of space.

The index is not entirely satisfactory. While the work of such men as Bohr, Lewis, Langmuir, and Millikan on atomic structure; of Acheson on electric furnace products; of Perkin (not Perkins) on dyes; of Cottrell on smoke precipitation is mentioned in the text, the index does not give any reference to these nor to Ostwald, whose process is given without credit under nitric acid. Neither text nor index gives any information concerning the work of Baekeland, Berzelius, Faraday, Morley, Remsen, Richards, and others. The book might be made more serviceable by inclusion of these and some other chemists, with correction of the index; the human interest side of the subject might also receive much more attention with a consequent increase in the value of the book for the beginner.

The appendix contains tables of solubilities, melting points, weights of a liter of different gases, and other useful information.

The half-tone illustrations are sometimes not sufficiently clear to be entirely satisfactory, while the pictures of chemists are still less clear in several cases. The drawings of apparatus by Mr. Schanck are good but it may be questioned if a simpler line drawing would not be more satisfactory than the ones in perspective which are difficult for pupils to reproduce.

The book is well printed on good paper and substantially bound. A few errors in the spelling of chemist's names and one or two mistakes in grammar were noted.

While there are several matters to be regretted, the book on the whole has much to commend it to the careful consideration of teachers of secondary school chemistry.

C. H. STONE
ENGLISH HIGH SCHOOL,
BOSTON, MASSACHUSETTS

**Laboratory Methods of Inorganic Chemistry.** HEINRICH BILTZ, Univ. of Kiel, and WILHELM BILTZ, Univ. of Göttingen. Translated by W. T. Hall and A. A. Blanchard, Massachusetts Institute of Technology. Second edition, 1928, John Wiley & Sons, New York, and Chapman & Hall, Ltd., London. xv + 261 pages. 27 figures. 15 × 22.5 cms. $2.50.

All who are familiar with the 1909 edition of this book will welcome this second edition. The translators have again faithfully followed the German text and adapted it to English students. "This book outlines a course of laboratory work which is essentially synthetic in nature and is designed to aid in acquiring a more adequate knowledge of inorganic chemistry than is obtained in qualitative and quantitative courses." The work contains 171 experiments each of which is the preparation of a definite compound or element. It is divided into seven chapters grouping together the different classes of reactions. The subjects covered are as follows: (1) The Obtaining of Pure Elements; (2) Changes of Condition; (3) Simple Compounds; (4) Compounds Containing a Complex Positive Component; (5) Compounds Containing a Complex Negative Component; (6) Complex Non-Electrolytes; (7) Preparation of Compounds of the Rare Elements from Their Minerals. Each different type of experiment is preceded by a brief discussion of the theory involved in the reaction, hence we find excellent short expositions on mass action, Werner's theory of complex ions, electrolytic dissociation, etc.

The new edition differs from the old only in that some of the discussions are made slightly longer. One variance from the 1909 edition is the inclusion of a short discussion on the periodic classification of the elements. This is in reality an excellent short review of the modern electronic theory of the structure of matter.

Some of the other changes worthy of mention are: the discussion on obtaining metals from fused salts is more satisfactory; the colloidal state is discussed more fully, the production of ammonia by the Haber process is used as well as the oxidation of sulfur dioxide to illustrate the commercial advantage of the law of mass action; under potassium iodide the recovery of iodine from organic residues is described; the preparations of potassium iodine tetrachloride and of phosphorous acid have been added; the discussions involving heterpolyacids and metal-ammonia compounds are slightly changed and more fully developed. The theory on isomeric salts is extended and this entire section with the exception of one experiment on chromium is now devoted to cobalt complexes.

This is an excellent book and in the words of the translators "should prove of value to manufacturing chemists as well as to students." The 1928 edition is better than the 1909 but there is not enough change to warrant one buying the former if he already has the older copy.

C. E. WHITE

UNIVERSITY OF MARYLAND

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**High-School Teachers and Chemical Society.** It seems to us that there are many high-school teachers who should belong to the American Chemical Society. What is the reason these teachers do not belong? Is it because of the cost? Are the programs too technical? Are the high-school teachers dead from the neck up? It would be interesting to know how many high-school teachers belonged in each section.

There are probably more teachers of high-school chemistry than there are college chemistry teachers, yet one seldom sees a high-school teacher at a sectional meeting of the society.

In as much as a majority of people get the only chemistry training they receive from high-school teachers, the American Chemical Society should be concerned with both the kind of teaching and the teaching personnel in the high school. Yet the society does not draw these teachers to its meetings. Should there be some investigation made as to what needs to be done to encourage high-school teachers to join the society and attend meetings?—*Isotopics*, **5**, 3 (Oct., 1928).